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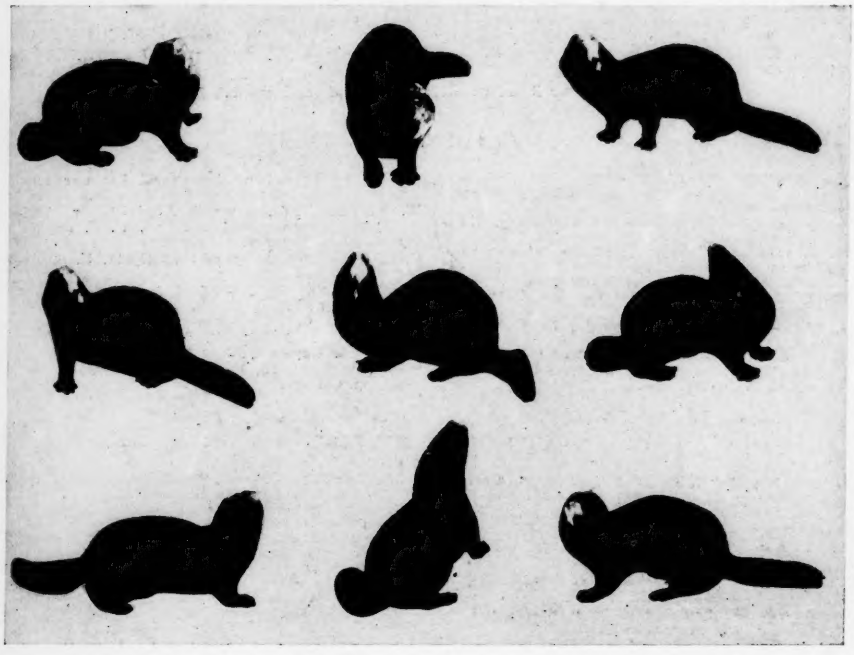

DANCE OF THE SCREW NECK PASTELS

(SEE PAGE 207)

A Seventeenth Century Description of Drosophila

The Wicked Callus and the Shattered Sorghum

Campus G.I.'s and the Differential Birthrate

The Multi-Factor Snowy-Belly Mouse and How It Come to Be

Multiple Color-Factors Open Treasure-Trove of Sesame Genetics

VOLUME 38 JULY, 1947 NUMBER 7

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The

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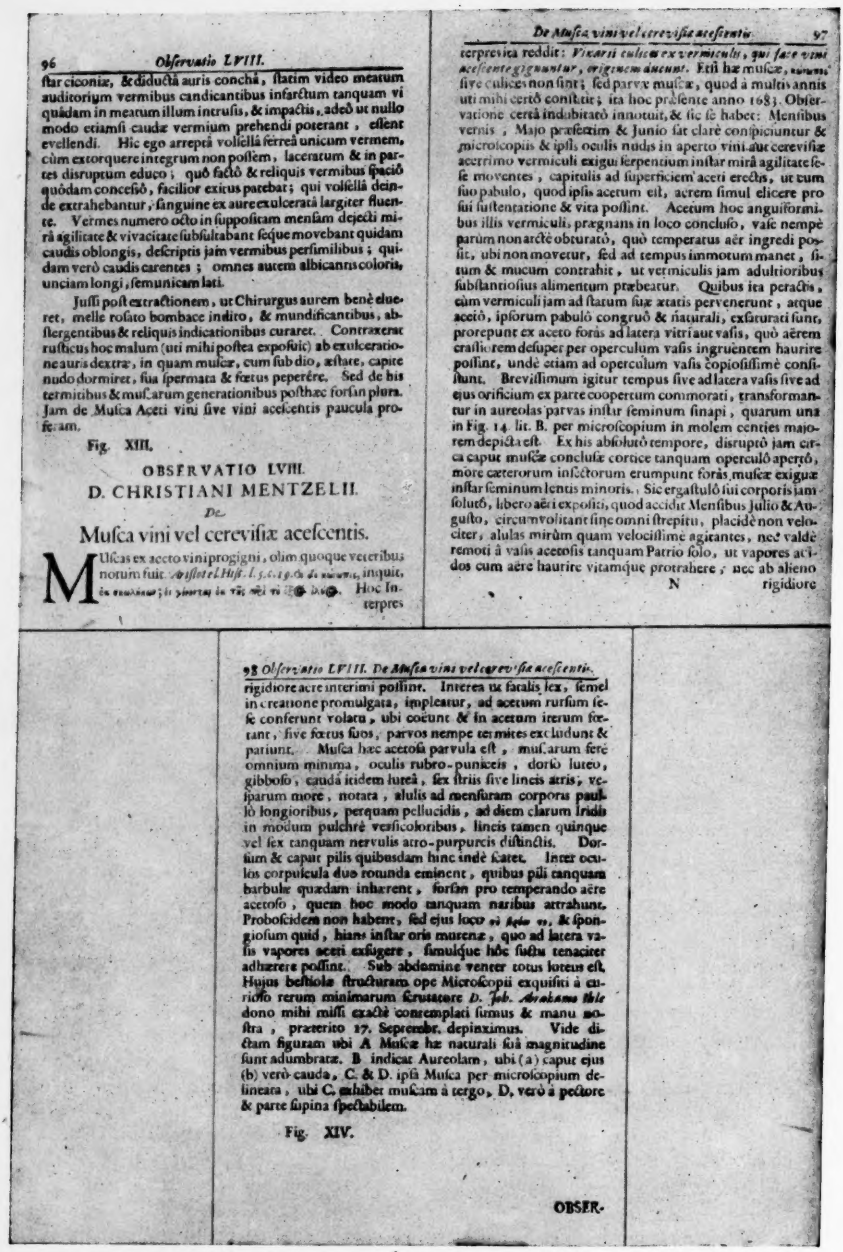


96 Observatio LVIII.

star ciconiæ, & deductâ auris conchâ, statim video meatum auditorium vermibus candicantibus infarctum tanquam vi quâdam in meatum illum intrusis, & impactis, adeò ut nullo modo etiamsi caudæ vermium prehendi poterant, essent evellendi. Hic ego arreptâ volsellâ ferreâ unicum vermem, cùm extorquere integrum non possem, laceratum & in partes disruptum educo; quò factò & reliquis vermibus spaciò quòdam concesso, facilior exitus parebat; qui volsellâ deinde extrahebantur, sanguine ex aure exulceratâ largiter fluente. Vermes numero octo in suppositam mensam dejecti mirâ agilitate & vivacitate subsultabant seque movebant quidam caudis oblongis, descriptis jam vermibus persimilibus; quidam verò caudis carentes; omnes autem albicantis coloris, unciam longi, semunciam lati.

Jussi post extractionem, ut Chirurgus aurem benè elueret, melle rosato bombace indito, & mundificantibus, abstergentibus & reliquis indicationibus curaret. Contraxerat rusticus hoc malum (uti mihi postea expositit) ab exulceratione auris dextræ, in quam muscæ, cum sub dio, æstate, capite nudo dormiret, sua spermata & fœtus peperêre. Sed de his termitibus & muscarum generationibus posthæc forsan plura. Jam de Musca Aceti vini sive vini acescentis paucula proferam.

Fig. XIII.

OBSERVATIO LVIII.

D. CHRISTIANI MENTZELII.

De

Musca vini vel cereviſiæ acescentis.

Muscas ex aceto vini progigni, olim quoque veteribus notum fuit. *Aristot. el Hist. l. 5. c. 19. de animal.* inquit, ἐκ τοῦ ὄξους γίνεται ἐν τῷ οἴνῳ τὸ ὄξος. Hoc Interpres

De Musca vini vel cereviſiæ acescentis. 97

terpres reddit: *Vinarii culices ex vermiculis, qui face vini acescente gignuntur, originem ducunt.* Etsi hæ muscæ, vermes, sive culices non sint; sed parvæ muscæ, quod à multis annis uti mihi certò constitit; ita hoc præsente anno 1683. Observatione certâ indubitatò innotuit, & sic se habet: Mensibus vernis, Majo præsertim & Junio sat clarè conspiciuntur & microscopiis & ipsis oculis nudis in aperto vini aut cereviæ acerrimo vermiculi exigui serpentium instar mirâ agilitate se se moventes, capitulis ad superficiem aceti erectis, ut cum suo pabulo, quod ipsis acetum est, aerem simul elicere pro sui sustentatione & vita possint. Acetum hoc anguiformibus illis vermiculis pregnans in loco concluso, vase nempè parum non arctè obturato, quò temperatus aër ingredi possit, ubi non movetur, sed ad tempus immotum manet, situm & mucum contrahit, ut vermiculis jam adultioribus substantiosius alimentum præbeatur. Quibus ita peractis, cùm vermiculi jam ad statum suæ ætatis pervenerunt, atque aceto, ipsorum pabulo congruò & naturali, exsaturati sunt, prorepunt ex aceto foràs ad latera vitri aut vasis, quò aërem crassiorem desuper per operculum vasis ingruentem haurire possint, undè etiam ad operculum vasis copiosissimè consistunt. Brevissimum igitur tempus sive ad latera vasis sive ad ejus orificium ex parte coopertum commorati, transformantur in aureolas parvas instar seminum sinapi, quarum una in Fig. 14. lit. B. per microscopium in molem centies majorem depicta est. Ex his absolutò tempore, disruptò jam circa caput muscæ concluse cortice tanquam operculò aperto, more cæterorum insectorum erumpunt foràs musca exiguæ instar seminum lentis minoris. Sic ergastulo sui corporis jam soluto, libero aëri expositi, quod accidit Mensibus Julio & Augusto, circumvolitant sine omni strepitu, placidè non velociter, alulas mirùm quam velocissimè agitantes, nec valdè remoti à vasis acetosis tanquam Patrio solo, ut vapores acidos cum aëre haurire vitamque protrahere; nec ab alieno

N rigidiore

98 Observatio LVIII. De Musca vini vel cereviſiæ acescentis.

rigidiore aere interimi possint. Interea tæ fatalis lex, semel in creatione promulgata, impleatur, ad acetum rursum sese conferunt volatu, ubi coëunt & in acetum iterum ferant, sive fœtus suos, parvos nempe termites excludunt & pariunt. Musca hæc acetosa parvula est, muscarum fere omnium minima, oculis rubro-puniceis, dorso luteo, gibboso, caudâ itidem luteâ, sex striis sive lineis atris, vesparum more, notata, alulis ad mensuram corporis paullò longioribus, perquam pellucidis, ad diem clarum Iridis in modum pulchrè versicoloribus, lineis tamen quinque vel sex tanquam nervulis atro-purpureis distinctis. Dorsum & caput pilis quibusdam hinc indè latet. Inter oculos corpuscula duo rotunda eminent, quibus pili tanquam barbulæ quædam inhærent, forsan pro temperando aëre acetoso, quem hoc modo tanquam naribus attrahunt. Proboscidem non habent, sed ejus loco τὸ ἄφιον, & spongiosum quid, hians instar oris murenæ, quo ad latera vasis vapores aceti exsugere, simulque hôc suctu tenaciter adhærere possint. Sub abdomine venter totus luteus est. Hujus bestiolæ structuram ope Microscopii exquisiti à curioso rerum minimarum scrutatore *D. Joh. Abrahamo Ihle* dono mihi missi exactè contemplati sumus & manu nostra, præterito 27. Septembr. depinximus. Vide dictam figuram ubi A Muscæ hæ naturali suâ magnitudine sunt adumbratæ. B indicat Aureolam, ubi (a) caput ejus (b) verò cauda, C. & D. ipsi Musca per microscopium delineata, ubi C. exhibet muscam à tergo, D. verò à pectore & parte supina spectabilem.

Fig. XIV.

OBSER-

GENESIS OF GENETICS—FROM LIGHT WINES AND BEER

Figure 1

Tiny flies, with six dark stripes on a yellow abdomen were described in 1683 by Christian Mentzel. The account was published in Nuremberg in the following year.

AN EARLY DESCRIPTION OF DROSOPHILA

B. PEYER
Zoologisches Museum der Universität Zürich

RECENT research has practically made Drosophila the domestic animal of biology. Therefore, it may be justified to call attention to one of the earliest manuscripts pertaining to Drosophila yet discovered, a description of the fly written by Christian Mentzel as early as 1683 and published in the following year in the periodical of the Academia Naturae Curiosorum (*Ephemerides,* Decuria II, Annus II, Observatio LVIII, Nuremberg 1684).* The paper being written in Latin, the question arose whether to give only a translation or a translation accompanied by the Latin original. The latter, though somewhat complicated, seemed to me preferable because it would have been too difficult a task to render by the translation not only the author's meaning, but at the same time to imitate the stylistic character of the Latin scientific publications of those days.

De musca vini vel cerevisiae acescentis

Muscas ex aceto vini progigni, olim quoque veteribus notum fuit. Aristotel. Hist. 1. 5 c. 19. οἱ δὲ κώνωπες, inquit, ἐκ σκωλήκων οἵ γίνονται ἐκ τῆς περὶ τὸ ὄξος ἰλύος. Hoc interpres ita reddit: Vinarii culices ex vermiculis, qui faece vini acescente gignuntur, originem ducunt. Etsi hae muscae κώνωπες sive culices non sint[1]; sed parvae muscae, quod a multis annis uti mihi certo constitit, ita hoc praesente anno 1683. Observatione certa indubitato innotuit et sic se habet:

Mensibus vernis, Majo praesertim et Junio sat clare conspiciuntur et microscopiis et ipsis oculis nudis in aperto vini aut cerevisiae acerrimo[2] vermiculi exigui serpentium instar mira agilitate[3] sese moventes, capitulis ad superficiem aceti erectis[4], ut cum suo pabulo, quod ipsis acetum est, aërem simul elicere pro sui sustentatione et vita possint. Acetum hoc anguiformibus illis vermiculis praegnans

On the fly of wine or beer turning sour

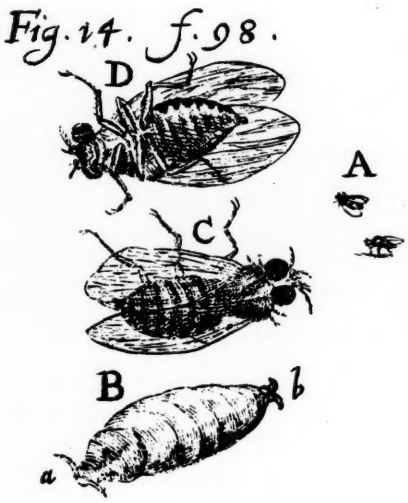
In days past, it has been known to the ancients too that flies arise from vinegar of wine. Aristotle, *Historia animalium,* book 5, chapter 19 says: "The gnats arise from small worms that originate in the dregs around the vinegar." The translator renders this passage as follows: The vinegar-gnats originate in small worms that proceed from the vinegar dregs. Still, these flies are no gnats† but little flies. This was clear to me for many years. In the present year 1683 it has been established beyond any doubt by reliable observation. The facts are these:

In spring-time, especially in May and June, one can see very distinctly by means of the microscope and even with the naked eye, small snakelike worms moving with astonishing agility[3] in open acid of wine or beer[2]. They raise their little heads to the surface of the vinegar[4] for the food, consisting of vinegar, and the air which are neces-

*Although no entomologist myself, I got acquainted with Mentzel's description of Drosophila by mere chance. For the bicentenary of the Naturforschende Gesellschaft in Zurich, I published a biography of the Swiss physician and naturalist, J. von Muralt. Into one of the plates accompanying Muralt's observations, the editor of the *Ephemerides* had inserted figures belonging to other observations and among them Mentzel's drawings of Drosophila. Professor E. Hadorn encouraged me to publish this little contribution to the history of natural science and it is to one of his students, H. Burla, that I am indebted for the necessary information about modern researches on Drosophila.—B. P.

†These references are to "Notes" on page 197.

in loco concluso, vase nempe parum non arcte obturato, quo temperatus aër ingredi possit, ubi non movetur, sed ad tempus immotum manet, situm et mucum contrahit, ut vermiculis jam adultioribus substantiosius alimentum praebeatur. Quibus ita peractis, cum vermiculi jam ad statum suae aetatis pervenerunt, atque aceto, ipsorum pabulo congruo et naturali, exsaturati sunt, prorepunt ex aceto foras ad latera vitri aut vasis, quo aërem crassiorem desuper per operculum vasis ingruentem haurire possint, unde etiam ad operculum vasis copiosissime consistunt. Brevissimum igitur tempus sive ad latera vasis sive ad ejus orificium ex parte coopertum commorati, transformantur in aureolas[5] parvas instar seminum sinapi, quarum una in Fig. 14 lit. B per microscopium in molem centies[6] majorem depicta est. Ex his absoluto tempore, disrupto jam circa caput muscae conclusae cortice tanquam operculo aperto[7], more caeterorum insectorum erumpunt foras muscae exiguae instar seminum lentis minoris[8]. Sic ergastulo corporis jam soluto, libero aëri expositi, quod accidit Mensibus Julio et Augusto, circumvolitant sine omni strepitu, placide non velociter, alulas mirum quam velocissime agitantes, nec valde remoti a vasis acetosis tanquam Patrio solo, ut vapores acidos cum aëre haurire vitamque protrahere, nec ab alieno rigidiore aëre interimi possint[9]. Interea ut fatalis lex, semel in creatione promulgata[10], impleatur, ad acetum rursum sese conferunt volatu, ubi coëunt et in acetum iterum foetant, sive foetus suos, parvos nempe termites excludunt et pariunt. Musca haec acetosa parvula est, muscarum fere omnium minima, oculis rubropuniceis, dorso luteo, gibboso[11], cauda itidem lutea, sex striis sive lineis[12] atris, vesparum more, notata, alulis ad mensuram corporis paulo longioribus, perquam pellucidis, ad diem clarum Iridis in modum pulchre versicoloribus, lineis tamen quinque vel sex tanquam nervulis atro-purpureis[13] distinctis. Dorsum et caput pilis quibusdam hinc inde scatet. Inter oculos corpuscula duo rotunda[14] eminent, quibus pili tanquam barbulae inhaerent, forsan pro temperando aëre acetoso, quem hoc modo tanquam naribus attrahunt. Proboscidem[15] non habent, sed ejus loco **τὸ βρύον τι** et spongiosum quid, hians instar oris murenae, quo ad latera vasis vasary for the maintenance of life. If this vinegar pregnant with those snakelike little worms is kept in a closed room, that means in a receptacle closed a bit but not tightly, so that some air can enter, and if it is not moved but remains still for a certain time, it develops mud and mucus, so that a more substantial food is provided for the worms which are now mature. When this has been carried out in that way and when the worms have arrived at maturity and are satiated with their convenient and natural food, the vinegar, they creep out of the vinegar to the wall of the glass or receptacle to breathe the thicker air that enters from above through the lid of the receptacle. Therefore they place themselves in great number even on the lid of the receptacle. Having stayed a very short time on the walls of the receptacle or on its half-closed lid, they are transformed into small chrysalides[5] of the size of a mustard-seed. One of them, magnified a hundred times by the microscope[6], is shown in Figure 14, letter B. Out of them, after a certain time, break forth in the way of other insects[7] tiny flies of the size of the seeds of the smaller lentil[8], the bark around the head of the enclosed fly having been broken in the same way that a lid is opened. The jail of their body is disintegrated and they are exposed to the open air. That happens in the months of July and August. They fly about without any noise, softly not quickly, and they move their little wings with astonishing velocity. They do not much venture forth from the vinegar-pots, their native soil, thus maintaining their lives by drawing in the vapours of vinegar and thereby protecting themselves against a rougher air[9]. Then, in order to fulfill the fateful law proclaimed in the days of creation[10], they fly back to the vinegar, where they copulate and conceive, bringing forth and emitting into the vinegar their fetus', namely little grubs. This vinegar-fly is very small, more or less the smallest of all flies. Its eyes are purple. The back is yellow and gibbous[11]. The tail also is yellow, signed by six dark wasp-like stripes or lines[12]. The small wings are a little longer than the body and very transparent. In bright day-light they are splendidly iridescent like a rainbow. They are signalized by five or six dark lines like dark purple-coloured[13] little nerves. Back



pores aceti exsugere, simulque hoc suctu tenaciter adhaerere possint. Sub abdomine venter totus luteus est. Hujus bestiolae structuram ope Microscopii exquisiti a curioso rerum minimarum scrutatore D. Joh. Abrahamo Ihle[16] dono mihi missi exacte contemplati sumus et manu nostra, praeterito 17. Septembr, depinximus. Vide dictam figuram ubi A Muscae hae naturali sua magnitudine sunt adumbratae. B indicat Aureolam, ubi (a) caput ejus (b) vero cauda, C et D ipsa Musca per microscopium delineata, ubi C. exhibet muscam a tergo D. vero a pectore et parte supina spectabilem.

"NO GNATS"

Figure 2

Mentzel's figure 14 shows enlarged views of his little flies, and of a pupa, correctly labelled as to fore and aft ends. The life-size sketch is an excellent reproduction of Drosophila.

and head are full of certain bristles on both sides. Between the eyes project two little rounded bodies[14] to which bristles are attached like little beards, perhaps for mitigating the vinegar-air that they draw in in this way as with nostrils. They have no proboscis[15], but have instead a certain *bryon* and something spongy yawning like the mouth of a muraena for sucking the vinegar-vapours on the wall of the receptacle and at the same time for sticking firmly to the wall by the act of sucking. Below the abdomen the whole belly is yellow. We did inspect accurately the structure of this little animal by means of an excellent microscope. This instrument has been sent to us as a present from Mr. Joh. Abraham Ihle[16], that inquisitive scrutineer of objects of small dimensions. Last September 17th we depicted the little animal with our own hand. See the figure mentioned, where in A these flies are outlined natural size. B shows the chrysallis, where (a) means the head and (b) the tail. C and D are the fly itself delineated through the microscope. C shows the fly from the back and D from the breast and the ventral side.

Notes

[1]The customary meaning of κώνωπες in Greek, *culices* in Latin, was gnats or mosquitoes. A *konopeion*, for instance, was a mosquito-net. Quoting Aristotle, the author therefore insists on the fact that the vinegar-fly is no gnat.

[2]*in aperto vini aut cerevisiae acerrimo:*— The exact meaning of this passage is not clear to me.

[3]*mira agilitate:*— The movements of the Drosophila-larva are not quick. Evidently the author made no distinction between the vinegar-eels and the real larvae of the vinegar-fly described by him at the same time.

[4]*capitulis ad superficiem aceti erectis:*— It is not the head but the hind part with the posterior spiracles that is exposed to the air for breathing. In the drawing of the pupa, the position of the head is correctly indicated.

[5]*aureolas:*— An unsuccessful attempt to Latinize the Greek term *Chrysallis* used by Pliny. In a previous paper on insects (*Ephemerides*, Dec. II, Annus I, Obs. 30, 1683), where the vinegar-fly is only briefly mentioned, Mentzel uses the term pupulas for puparia.

[6]*centies majorem:*— Ten times linear.

[7]*tanquam operculo aperto:*— The observation is excellent.

[8]*seminum lentis minoris:*— *Lens culinaris Medicus.* The seeds of this plant cultivated from times immemorial differ considerably in size in its numerous subspecies and varieties. The smallest seeds correspond to the comparison.

[9]*nec ab alieno rigidiore aëre interimi possint:*— The passage shows that Mentzel did not know the wild species of Drosophila.

[10]*fatalis lex:*— Genesis 1, 22. "Be fruitful and multiply." The emphasis of this quotation seems to mark the contrast to Aristotle's doctrine of a *generatio spontanea.*

[11]*dorso gibboso:*— Probably the contour of the anterior part of the mesonotum in lateral view.

[12]*cauda:*— The abdomen.

[13]*nervulis atropurpureis:*— The statement seems to be incorrect; see "Discussion" below.

[14]*corpuscula duo rotunda:*— The antennae.

[15]*proboscidem non habent:*— In the modern sense, Drosophila has a proboscis though different from that of the Lepidoptera. What the author describes as *bryon ti* and *spongiosum quid,* are parts of the proboscis. *Bryon* has two significations, that of moss and that of catkins of plants. The comparison seems to rest on the latter meaning. *Spongiosum quid* unmistakably signifies the oral lobes of the proboscis.

[16]Joh. Abraham Ihle:— Friend of Mentzel. He lived at Leipsic. Together with his friend, he had published in the *Ephemerides* of the foregoing year, 1683 (Dec. II, Annus I, p. 71) the *Observatio de muscis quibusdam culiciformibus, pediculosis, grylliformibus et aliis.*

Discussion

As to the question which species of Drosophila may have been described by Mentzel, modern "drosophilosophers" explained to me that in all probability it must have been *D. melanogaster*; only the outlines of the puparium do not support this interpretation. At any rate, it must have been not a wild species, but a domestic one, from among the palaearctic species *melanogaster, simulans, funebris, immigrans* and *Kuntzei.* That the species described by Mentzel may have been extinct or become very rare in the meantime, is not probable. Nearly all the indications given in the description —eyes purple; mesonotum yellow; abdomen yellow with six black bands (females!); wings very transparent and iridescent; belly (comprising the ventral plates of the abdomen) yellow—refer to *melanogaster* and to *simulans.* The only passage of the description that does not correspond to any palaearctic species of Drosophila at all is *"nervulis atropurpureis."* The veination of the wings is always either yellow or brownish yellow in the case of *melanogaster,* but never purple. The erroneous statement of Mentzel may be due to observation in transmitted light. The published drawings, though showing rather well the general characters, are not sufficient for modern specific determination. In the puparium (Figure 2*B*) for instance, the cast mouth armature visible through the pupa-case and common to dipteranymphs is carefully delineated, whilst the outlines of the anterior spiracles are not rendered accurately enough to permit a determination of the species.

Christian Mentzel, 1622-1701

The author of this description of Drosophila, Christian Mentzel, was born at Fürstenwalde in Brandenburg, June 22, 1622. He died in Berlin, January 17, 1701. An M.D. of the University of Padua in 1654, a distinguished physician, he became a member of the Academia Naturae Curiosorum in 1675. He is chiefly known by his botanical works, especially by the *Index nominum plantarum universalis,* Berlin 1682, and by linguistic and historical studies on China. Many of his minor writings have been published as *"Observationes"* in the *Ephemerides*; these treat partly of medical questions, partly of various branches of natural history. Nine of them are on insects. An excellent anonymous biography of Mentzel appeared in *Ephemerides,* Dec. III, Annus VII and VIII, 1702, Appendix p. 193.

Mentzel's description of Drosophila shows the difficulties early entomological workers had to overcome and at the same time the low rates of diffusion of new scientific results. The way in which he treats the problems of respiration proves that he was not yet acquainted with Malpighi's *De bombyce,* published 1669, and with the discoveries of Jan Swammerdam. During his studies, Mentzel had seen a good deal of Europe and paid a visit to Holland, but that had

been long before the beginning of Swammerdam's researches. On the other hand, it must be taken into consideration that Swammerdam's famous *Bible of Nature* was not published until 1737-1738, more than fifty years after its completion. Professional duties did not permit Mentzel to specialize in entomological anatomy and thus vie with the founders of modern entomology. Nevertheless the fact that he did not recoil from investigating, describing and drawing so small an object as Drosophila, aided only by the modest microscopes of those days, is a tribute to his scientific spirit that deserves acknowledgment. As it is not possible to discuss Mentzel's other entomological observations in this short article, the reader is referred to E. C. Cole's *History of Comparative Anatomy,* London 1944, where they are honorably mentioned.

✦

THE G.I. AT COLLEGE

An opportunity for Eugenics

THE present invasion of college campuses by married G.I.'s with their wives and children constitutes a revolution unequalled in the history of American education. In our opinion it furnishes the essential key to the problem of how to promote early marriages and a high birthrate among college students, which thus far has defied the ingenuity of eugenists. At precisely the time of life when they are attending college the students are biologically better fitted for parenthood than they will ever be again. Their youthful idealism untarnished by the sordid competitive struggle for gain, they are under the daily supervision and guidance of adults who are convinced of the need for a eugenic revision of birth-rates. Heretofore the colleges have been hostile to undergraduate marriages, but the G.I. Bill of Rights seems to be rapidly changing this.

At least two schools in the United States are now experimenting with the care of very young children as part of the curriculum in the attempt to give their students experience of real life—the Daniel Webster High School at Tulsa, Oklahoma, and Iowa State College. Unfortunately the latter—whose undergraduates are old enough to marry and have children—has been unable to obtain funds with which to enlarge their nursery-school facilities so as to take care of the children of the students themselves as well as those of outsiders. This is a typical illustration of the way in which the more socially intelligent members of a society are restrained by the less socially intelligent from carrying out their purposes—a phenomenon particularly menacing when it comes to eugenics since it controls not only the course of the present society but the inborn constitution of coming generations. The true educator, seeking the maximum of academic freedom, finds himself forced to compromise on vital points by the very society he is seeking to serve. Thus education is caught in a vicious circle from which it can only with great difficulty extricate itself. This problem is of course not peculiar to the schools; it is part of the larger problem of mankind, and, indeed, of the evolutionary process itself. Progress can, in general, take place only through the segregation of the more progressive from the less progressive elements, and the problem is how to achieve this in human society without doing violence to our democratic standards and ideals.

Reproductive Dead-End

The historian, Arnold Toynbee, takes a pessimistic view of the future of our civilization. According to him, all past civilizations have fallen through the same cause: Creative minorities have lost their creativeness. (The same view was held and ably expounded by John Stuart Mill in his book *Liberty,* wherein he presented an amazing prophecy of conditions existing in Europe today.) By far the

most creative minorities in our nation today are to be found in the colleges and universities. Unfortunately among these minorities, upon which the future of America depends, are found some of the lowest birth-rates in the world. There is nothing more tragic and heartrending than this spectacle of childless families among the intelligent, highminded and idealistic just at the time when modern technology has placed an era of unparalleled progress and opportunity almost within our grasp.

Eugenists heretofore have sought to promote their cause through legislation and economic reform. They have proceeded upon the assumption that society as a whole must be changed before it can be changed in any of its parts; that great masses of men must be moved before a small minority can be induced to act. The birth-rate has been regarded as so intimately tied up with social and economic factors as to be practically inseparable from them.

The outstanding disadvantage of such a method of approach lies in the fact that it will be effective only in dealing with issues which have a natural appeal for large masses of people, whereas mankind at large has never shown any ability to think intelligently when it comes to such matters as that of directing its own evolution. The result has been that the cause of positive eugenics has remained in a condition of virtual stalemate ever since it was first proposed by Galton. Social enthusiasm has followed the more short-sighted channels, and the eugenists have never been able to win a sufficiently large following to secure concrete results.

May it not be that they have put the cart before the horse; that progress in this field must take place in small groups before it can occur in society at large? How else are we to secure the leadership necessary for the transformation of society? It is our thesis that this is the case; that the eugenically-minded must in some way be segregated and brought together to promote intermarriage with resultant production of cones of eugenic leadership. According to Paul Popenoe, there are several hundred thousand of these family-minded individuals in the United States today—persons who are having large families because they believe in life. Surely this is enough to start a real going concern in the realm of positive eugenics! The problem is how to secure contacts between them and create a sense of solidarity among them.

G.I. Eugenics

It is our conviction that the G.I. Bill of Rights and the present trend toward family-life education in the colleges and universities will prove the entering wedge by which such a development can be brought about. There are many men in our colleges today who are anxious to promote the cause of eugenics, but unfortunately as yet they have not been able to devise a plan having all the necessary factors for success. Ely Culbertson, in working out the Quota Force Plan — the only effective method for world peace yet devised* — has shown us the need for sound strategy when it comes to any kind of long-range program. The keynote of his plan is the way in which it unites the qualities of effectiveness with those of acceptability. This is what eugenics has lacked. The current proposals of the eugenists might be effective if put into operation, but they lack the quality of acceptability. And, contrariwise, the types of social reform which have high acceptability among our present voting population are in general entirely lacking in eugenic value. The supreme need of our day is to do for eugenics what Mr. Culbertson has suggested might be done for world peace.

We believe that the eugenists in our colleges will find their opportunity in the new educational developments. It is a pecular stroke of good fortune that the type of education which is best from a

*Experts in the field of international relations, to whom copies of the plan have been mailed have failed to find a single serious flaw in it. Its great unifying power is revealed in the diversity of the political groups accepting it.

purely educational standpoint is also most desirable from a eugenic point of view. Educators have long been stressing the importance of developing the individuality of their students, and they have seen that in order to do this they must give the latter experience of life. But as marriage and parenthood are integral parts of life, these too should be included in the curriculum if the students are to have the maximum of such experience. It is this consideration, together with the G.I. influx, which is prompting certain of the more forward-looking American educators to follow the example of the Swedish educational system, where marriage and parenthood among undergraduates are systematically encouraged. The educator and marriage counsellor wish to see these all-important functions of adult life incorporated into the curriculum because only in this way can the students obtain experience of the things about which they are taught at a time when adult supervision and guidance are available. The eugenist wishes to see them so included because only in this way can we bridge effectively the disastrous time-span between biological and vocational maturity which is killing off our finest racial stock.

We have called attention to the way in which the more creative elements in a society are restrained by the less creative from accomplishing their purposes. In the case of education this restraining influence is due to the necessity for relying upon the uncreative majorities for funds with which to carry on the program, with resultant loss of academic freedom. In a day when it is becoming more and more difficult to secure funds with which to finance new educational experiments, this places an almost insuperable obstacle in the path of the progressive educator.

Cooperative Education—A Way Out

It is here that we should like to call attention to an educational project which seems as though specially devised for the purpose of solving our problem. Some 28 years ago, in a cornfield near Siloam Springs, Arkansas, a small group of idealists launched a school which has since become a Mecca for educators seeking a way out of the economic impasse. From a humble beginning the college and university have grown into a model community with electric light and power plant, garage, welding department, furniture factory, Jersey herd, irrigated gardens, publishing-house, dressmaking department, canning department, bank, student housing, etc., all on a cash basis, as part of the curriculum, and able to meet all its financial obligations during the stock-market crash and depression of the '30's when other schools were closing by the score.

"To our grounds leading men of the nation have come—one group on a special train. Statesmen, educators, newspaper men, preachers, financiers, tillers of the soil, day laborers, have united in the declaration that here is the type of an educational program that America stands in desperate need of. For fourteen years there has gone out a stream of students that, by actual test through a questionnanre sent out, have demonstrated their ability to carry their work as students. Our students in other schools of the states, with every possible discount, have shown much better than the average student. . . .", pp. 70-71, *Is Our Modern System of Education Doomed?* by John E. Brown.

"As I dictate this article girls are busy in the kitchens and dining rooms preparing our noon day meal. The meal will come from our irrigated gardens, our farms, our vineyards, our Jersey herds, and poultry yards produced by the hands of our students. The tables at which we sit, and the chairs, and even the building itself, were built by student hands. Our light and power come from a plant erected and operated by students. Around me as I write are the busy activities that center in a new building now under construction. In a large publishing house, in our general stores, in the garage, electric shop, and dress factory, these students work under skilled instructors. They are not only producing a little city here on College Hill, and operating this city, but they are demonstrating the pos-

sibility and the realities of a practical education, without breaking the hearts of their parents and without breaking the backs of taxpayers. Students cannot work four hours a day and carry academic work? Well, thank God, they are doing it! A school cannot be operated where a three-fold training can be secured at the cost of three hundred dollars a year, and half that amount carried by note? Well, thank God, they are doing it!" (*ibid*).

Here is the solution to the problem of how to obtain the needed funds and at the same time retain academic freedom, which is going to loom so large in the years that lie ahead as educators and eugenists seek to incorporate the new family-unit system of education made imperative by the breakdown of the home and rising tide of divorce resulting from our increasingly complex industrial civilization. We need a sort of extension of the home to meet the complex conditions of our modern urban society. The alarming increase in divorces shows that the home is not meeting the problems facing it. The colleges can best provide this extension because there the young parents starting out in life will have the daily guidance and instruction of experts at the time when they need it. According to Paul Popenoe, three-quarters of undergraduate marriages are successful. The proportion would be greatly increased under a family-unit system of education similar to that in Sweden.

The writer submits that this situation offers eugenists a unique opportunity, and commends it to their consideration.

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ON TO STOCKHOLM!

Genetics Congress Travel Plans

THE Clara Laughlin Travel Services, Inc., located at 38 East 57th Street, New York 22, N. Y., has been appointed official agent by the Travel Committee of the Genetic Society of America to handle travel arrangements to the International Genetics Congress in Stockholm July 7-14, 1948. If you have not already indicated your desire to attend by returning the preliminary questionnaire card, please notify the agent immediately. Steamship rates each way are:

	Direct to Sweden	*Via England or France*
First class, from	$285.00	$385.00
Cabin class, from	220.00	285.00
Tourist, from	180.00	225.00

Airplane rates are: round trip to Stockholm $730.30; one way $405.00; one way London to Stockholm, $96.00.

There is an opportunity to organize trips to other countries either before or after the Congress. The agent plans to send out a questionnaire to all who indicate a desire to attend the Conference. Travel conditions are difficult, and boat, plane and hotel reservations are hard to get. Therefore your prompt handling of the agent's questionnaire is essential if reservations are to be assured.

"SCREW NECK" IN THE PASTEL COLOR PHASE OF RANCH-BRED MINK*

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A COLOR phase which is at the present time called pastel by mink breeders has appeared in herds of natural dark (wild type) ranch-bred mink in several localities of the United States. This color phase has been designated by several names, among them chocolate, blond, golden sable and royal pastel. Shackelford,[12] Smith, *et al.*,[13] and Castle and Moore[2] have reported this mutation to be an autosomal recessive. It appears to be the same as the chocolate mutation in other species of mammals. An abnormal behavior pattern which has been termed "screw neck" by many ranchers is characteristic of some "brown eyed" pastels.

Pastel mink differ in color from the natural dark ranch mink in the lighter brown color of the pelage, eyes, nose, lips and claws. In some individuals the eyes are very light brown, almost a red-brown, while in others the eyes are nearly as dark as in natural dark mink. The lighter color seems to be the result of certain changes in the melanin pigment characteristic of natural dark mink. The quantity of melanin in the fur is reduced appreciably, the granules are smaller, and the color of the granules lighter (unpublished data).

All of the different strains of pastel appear to be the result of a mutation at the same locus with the exception of a strain sometimes called "green eyed" pastel (also "golden cross"). The latter is reported by ranchers to produce only natural dark kits when mated to any of the other strains. The reported number of such matings is very small, and the circumstances under which the matings were made suggest that more matings under controlled conditions are needed before this interpretation can be accepted.

A number of characteristics of the "green eyed" pastels, however, strongly supports the possibility that this strain is genetically different from the others. The peculiar eye color of the "green eyed" pastels is so pronounced in comparison to the eye color of the other pastels as to indicate a genetic difference. Screw neck has not been reported in this group. We have examined more than 50 "green eyed" pastels and none has shown the symptoms of this condition.

Pastel mink are bred at present in relatively large numbers as a result of their popularity with the fur trade. It was only with the increase in numbers that screw neck came to be generally recognized as a condition that occurred regularly in varying proportions among pastels. The majority of pastel mink do not show screw neck symptoms, and since there is no indication that the condition in any way interferes with fecundity or pelt production, it is probably of little economic importance.

Description of Screw Neck

Individuals affected with screw neck show the symptoms of this condition by carrying the head tilted habitually either to the right, or to the left, or in some individuals by tilting it first one way and then the other. When turning around in a cage (especially in the corners) the head is thrown directly over the shoulder or back. If an individual showing pronounced affection is being observed while in a standing position, it will often look directly at the observer with the

*Joint contribution from the Departments of Genetics (Paper No. 368) and Veterinary Science. Supported in part by Wisconsin Agricultural Experiment Station Project 614, Fur Farm Research. Published with the approval of the Director of the Station.

characteristic tilt and, if not disturbed, will rotate its head until the ventral side points upward.

When disturbed or frightened these symptoms are accentuated and some pastels that appear normal when not molested will show unmistakable screw neck signs under such conditions. Screw neck individuals are usually reluctant to leave the nest box when disturbed, and if forced out into the cage, the tilting of the head is especially evident as they leave the nest box. If disturbance is continued, inability to cling to the inside of the cage or nest box in a normal manner is shown and the mink races about wildly exhibiting a general lack of coordination in its movements. A few individuals that are affected only slightly when undisturbed turn a series of perfect forward somersaults after being chased from the nest box and allowed to quiet themselves.

Lack of the ability to cling to objects in a normal manner when excited can often be demonstrated if an affected individual is forced to the ground from the nest box. Instead of holding to the outside of the box, head downward, and then jumping to the ground, such a pastel will jump upward with the body in a vertical position and more or less maintain this position while falling to the ground. After being liberated it will move forward in a direct line as do normal individuals, but if again disturbed will run in wide circles, sometimes to the right and sometimes to the left.

Observations of Pastels on a Commercial Ranch

One ranch which produces a large number of pastel mink kindly allowed us to observe and classify their animals. The records presented here, as well as many of the detailed observations of the behavior of screw neck individuals, were taken from this ranch.

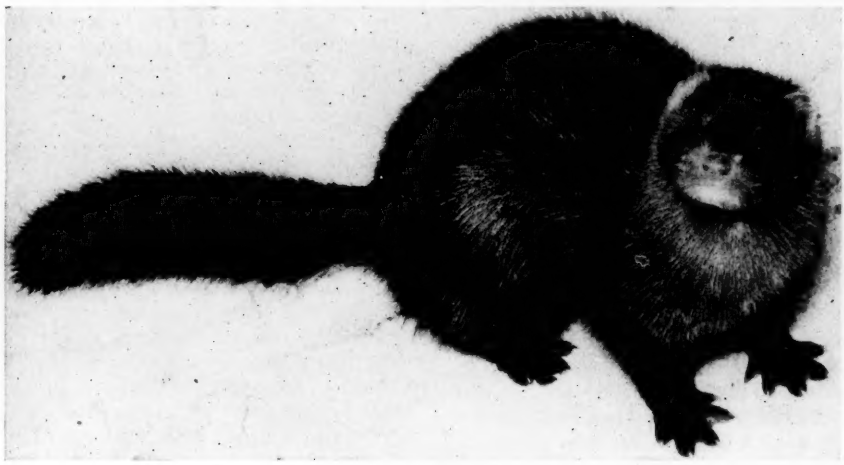
The pastel color phase first appeared on this ranch among the offspring of two natural dark mink about ten years ago. The original mutation to pastel may have occurred on this ranch. These mutants, however, have produced only pastel kits when bred to any of the other strains of brown eyed pastels, and presumably are representative of pastels in general. All pastels on this ranch are descended from the original heterozygous pair, although a few have been reintroduced, their pastel progenitors having been sold to other ranchers a few generations previously.

The first few individuals of this mutant color phase were not observed to be affected, but as soon as individuals showing screw neck symptoms appeared they were eliminated. In spite of this rigid selection, about the same proportions of affected pastel kits occur every year according to the owners.

All of the pastel kits observed were born in the 1946 breeding season and were classified the following September. As just indicated, none of their parents were screw neck individuals. At the time of examination each kit occupied a separate cage, the males in one section and the females in another. The standard procedure in observing and classifying a random sample of these pastel mink was to chase each mink from the nest box, pass a lead pencil across the wire at the end of the cage opposite the nest box two or three times, and allow the individual to quiet itself. To indicate the varying degrees of affection, the mink were classified into four groups ranging from "none" to "extreme."

Female mink with new-born young are customarily not disturbed for several days unless there are indications that something is amiss; hence, the litter size at birth is seldom known on commercial ranches. On this ranch each litter was examined and the number of each color phase recorded by the time the kits were from four to six weeks of age. This first record has been taken as normal in considering litter size, although some kits have no doubt died by the time the litter is a month old.

Approximately 600 pastel kits were available for examination. All observations were made on the basis of pheno-



PASTEL PLUTOCRAT
Figure 3

The "brown-eyed" pastel is a mutation recessive to normal color, and apparently homologous with chocolate in other mammals. It has proved to be very popular in the fur trade, and is today bred in large numbers. A peculiarity of the pastel strain is that about a quarter of all pastel animals are "screw necks,"—twisting the neck to one side (See Figure 4), especially when disturbed. Since this peculiar behavior is limited to pastel individuals, and since it occurs with about the same frequency in all strains of "brown-eyed" pastels, it is probable that this odd behavior is a pleiotropic manifestation of the pastel gene.

type, that is, the color phase of the individual, and not upon whether they had been produced by a homozygous × homozygous mating or a homozygous × heterozygous mating, these being the two types of matings practiced on this ranch.

Results

Table I shows the results of classifying 309 pastels; 25 per cent of the males and 24.2 per cent of the females showed screw neck symptoms in some degree. No females in this group were observed to tilt their heads in both directions, but two pastel females in our experimental herd* regularly tilt their heads in both directions. Although no individuals were seen that could be called "extreme," one pastel kit observed on another ranch when about three months of age was able to stand erect only with great difficulty, and habitually took its food in a reclining position.

If the expression of this character is in some measure dependent upon the action of recessive genes, one would expect the frequency of screw neck individuals to be higher in an inbred than in a non-inbred group. Considerable inbreeding has been practiced on this ranch to produce the maximum number of pastel mink in the shortest time. The dark mothers (heterozygous for pastel) were

TABLE I. Classification of 309 Pastel Mink Produced on a Commercial Ranch in the 1946 Breeding Season.

Sex	Total Observed	Total Affected	Degree of Affection				% Affected	Tilt		
			None	Slight	Decided	Extreme		right	left	right & left
Male	148	37	111	30	7	0	25.0	21	12	4
Female	161	39	122	27	12	0	24.2	21	18	0

*Cooperative experiments with the Wisconsin Conservation Department's Experimental Game and Fur Farm, Poynette.

either slightly inbred or not inbred at all, whereas the pastel mothers were produced by a fairly intense inbreeding scheme. The male parents were homozygous for the pastel gene in all matings. These data were divided into two groups on this basis as shown in the first column of Table II. There is no evidence that the percentage of screw neck kits is greater among inbred than among non-inbred pastels ($P > 50$ per cent < 95 per cent).

Observations were made on a random sample of 309 pastel kits; the classification on the basis of type mating which produced them (Table II) was not made until after the observations had been recorded. A check of the records revealed that in several cases all of the pastel offspring from a given female had not been observed. This occurred because some of the kits may have died between the time of first checking and the time of these observations, because they happened to be in the group of pastels which were not observed, or a combination of these two circumstances. It should be borne in mind that with the exceptions just noted, the entire litter from pastel × pastel matings was seen at the time of these observations, but from pastel × dark (heterozygous for pastel) matings only the pastel kits were seen.

The kits have been grouped according to whether or not all pastel sibs have been examined (Table II). In those litters in which all the pastels were present at the time of observation, pastel mothers (homozygous for pastel) produced 26.1 per cent screw necks, and dark mothers (heterozygous for pastel) produced 16.9 per cent. There is no significant difference between pastel and dark mothers in the proportion of their pastel kits that are screw necks ($P >$ 10 per cent) when all pastel kits have been observed.

No significant difference is shown in the proportion of screw neck pastels between pastel mothers whose entire litter was seen in each case and pastel mothers where only part of each litter was seen ($P > 20$ per cent < 30 per cent).

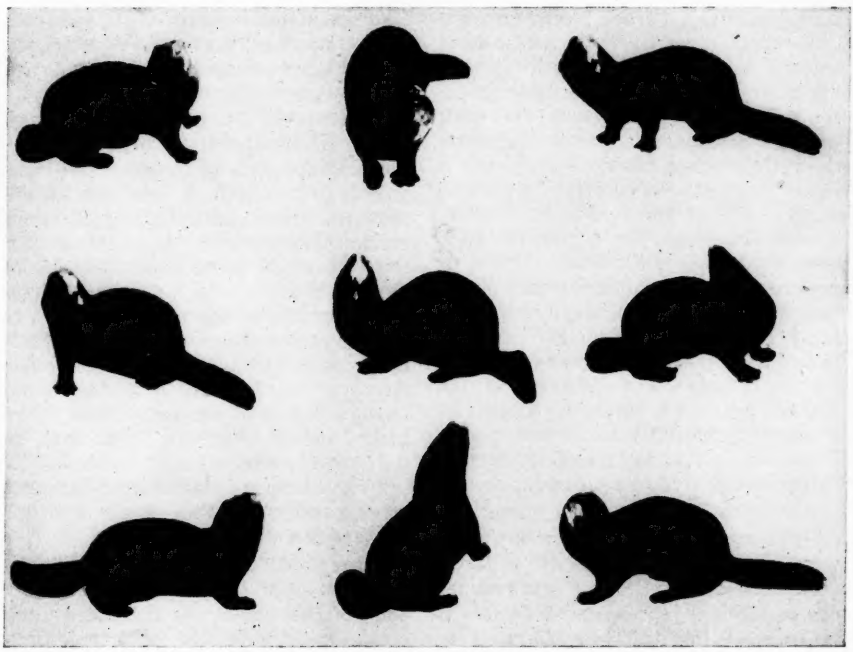
The dark mothers with only part of their litter seen, however, have a significantly greater proportion of screw neck pastels than do either the dark mothers where the entire litter was seen ($P < 1$ per cent), or the pastel mothers where only one part of the entire litter was seen (P equals approximately 4 per cent). Individual screw necks often show considerable variation in degree of affection from one day to another; that is, at times they show normal behavior and at other times unmistakable symptoms of the condition. Considering the variability of the screw neck character, these differences, although statistically significant, may be due to errors in classification. If not, no clear-cut interpretation of these differences is evident.

Discussion

Inherited behavior patterns differing in varying degrees from the normal are known in several species of animals. Probably the oldest and best known example is the case of the Japanese waltzing mouse, which has been discussed in detail by Gates.[4] Laanes and

TABLE II. Classification of Pastel Mink from Table I Based on the Type Mating by Which They were Produced.

Mothers		Kits Observed	All of Litter Seen	Only Part of Litter Seen	Kits Not Seen
Pastel	Total Number	199	115	84	41 (32.8%)
	Number Affected	51	30	21	
	% Affected	25.6	26.1	25.0	
Dark (Heterozygous for Pastel)	Total Number	110	89	21	8 (27.5%)
	Number Affected	25	15	10	
	% Affected	22.7	16.9	47.6	



PASTEL POSTURING

Figure 4

Photographs of six "screw neck" pastel individuals showing characteristic twisting or tilting of head. Most of the affected individuals tilt the head either to the right or to the left, but some tilt it to either side. When turning around the head is thrown back over the shoulder, and some animals turn complete somersaults. The behavior of these animals resembles the inherited neurological and behavior disturbances observed in several other species of mammals. It is unusual in that in the case of the "screw neck" pastel, there is a complete association with a color pattern.

MacDowell[7] have described circling as a two-gene trait in the mouse. Lord and Gates[8] found shaker, another nervous condition in the mouse. Grűneberg[5] has reviewed the literature in regard to the entire shaker-waltzer-circler group in the house mouse. Woolley and Dickie[15] reported pirouetting in the mouse. In Peromyscus, Watson[14] has described epilepsy and waltzing in six different stocks. Bonhote[1] has described waltzing in *Mus rattus*. King[6] discovered waltzing in her albino rat colony. Lush[9] has reported a herd of goats in which nervousness is characteristic of all individuals. Cole and Ibsen[3] found congenital palsy in a colony of guinea pigs, and in their report have discussed briefly the peculiar behavior pattern in Tumbler pigeons. A condition termed "hereditary ataxia (?)" has been reported by Riddle[11] in pigeons. Nachtsheim[10] has studied several types of nervous conditions in the rabbit.

The screw neck pastels have two characteristics in common with the aberrant types in the above mentioned species: an accentuation of the nervous symptoms when frightened, surprised, or faced with a novel situation; and none inherit their particular behavior pattern as a simple dominant. In many respects the behavior of screw neck pastels is similar to the shaker mice of Lord and

Gates[8] who say, "When placed on a flat surface, the animal will throw the head backwards, or twist the anterior part of the body to one side." Grüneberg described waltzers in almost the same words. Screw neck pastels regularly show these same reactions, although it is not necessary to confront them with an unusual situation to elicit this response. For example, during the 1946 breeding season one of our screw neck females twisted the anterior part of her body to the left so consistently on entering her nest that the fur on her back looked as if it had been combed toward the right side. The behavior of the shaker mice and screw neck pastels also corresponds in that both can and usually do move in a straight line in familiar surroundings if not disturbed.

About 25 per cent of the pastel kits on the commercial ranch where they were observed were classified as screw neck individuals. If these observations can be taken as representative of the expression of this behavior character in mink, it follows that the majority of individuals homozygous for pastel do not show screw neck symptoms.

In several of the species already mentioned, animals that were known by pedigrees to be homozygous for their special behavior pattern were normal in behavior. Nachtsheim[10] found only seven of ten offspring from "nervous" parents which exhibited "nervous" symptoms. Laanes and MacDowell[7] found 17 per cent of such "normal overlaps" in the house mouse. Watson found overlaps in several species of *Peromyscus:* 14.4 per cent of *artemisae* individuals showing both shaker and epileptic symptoms, 6.1 per cent showing epileptic symptoms only; 1 individual in *erminicus*; 3 individuals in *bairdii*. In Dobrovolskaia-Zavadskaia's somersaulting mice, overlaps appear to be common according to Grüneberg. In her report of waltzing in the rat, King says, "Available evidence seems to indicate that waltzing is due to a single gene, but that the extent to which this gene expresses itself depends upon modifying factors which favor or inhibit its action." In the sixth generation of selection for the most pronounced waltzers, the percentage of waltzers produced by waltzing parents had risen to 93 per cent.

The behavior of screw neck pastels in normal surroundings ranges from individuals which differ slightly from the normal to those which can scarcely stand erect. Furthermore, breeders report that the screw neck symptoms usually tend to become less pronounced with age. The same individual may show a great amount of variation, being decidedly affected some days and on other days varying little from normal in behavior. Eight of the individuals (four males and four females) classified as only slightly affected, so far as head tilting was concerned, varied from the other screw necks in that they regularly turned forward somersaults.

Some breeders have expressed the opinion that all pastel mink would show some manifestations of the screw neck condition if frightened or teased for a sufficiently long period. It is probable that many but not all pastels would express screw neck symptoms under adverse circumstances. Four pastels in our experimental herd have been subjected to a number of disturbing situations at intervals over a period of a year; three of them always show screw neck symptoms to some degree, while one of them behaves normally. Pastel mink are too valuable at present to allow for exhaustive experiments of this type.

The association of abnormal behavior patterns and coat color has been reported in only one other mammal to our knowledge. One of the "nervous" conditions in rabbits investigated by Nachtsheim[10] occurred only in Vienna Whites and he considered it an allel of Vienna White according to the scheme X = non-Vienna White, x = Vienna White, X_e = "nervous" Vienna White.

We have observed certain peculiarities in the behavior of the pearl platinum color phase of the silver fox, on some ranches, but these peculiarities of be-

havior are by no means common among all pearl platinums and therefore may possibly bear no relation to color phase. In mink two general observations suggest that screw neck and pastel are possibly pleiotropic expressions of the same mutation: mink breeders as a group select against screw neck, yet affected kits appear regularly among the pastels each year; pastel mink from herds into which the pastel gene had been introduced from unrelated individuals also have screw neck individuals in about the same proportions as if produced in a closed herd. We have never observed a group of pastels consisting of as many as ten individuals that did not contain some showing screw neck symptoms.

None of the other color phases of mink have been reported to show the symptoms characteristic of the screw neck condition. Mink are notoriously active animals and usually spend a considerable portion of the time running back and forth in their cages. As is true of many caged animals, mink often develop peculiar habits of running or turning when confined in familiar surroundings. Such individual habits should not be confused with the screw neck symptoms.

Summary

1. The pastel mutation (brown eyed) of ranch-bred mink, which is presumably the same as the chocolate mutation in other mammals, has associated with it a behavior pattern called "screw neck."

2. Approximately one-fourth of the pastel kits observed on one commercial ranch showed screw neck symptoms.

3. The screw neck syndrome varies from almost normal behavior to the inability to stand erect; further, individual screw necks show varying degrees of affection from day to day.

4. Neither outbreeding nor selection against this behavior pattern appears to have reduced the proportion of screw necks among the pastel kits.

5. Screw neck is apparently one of the effects of the pastel mutation which expresses itself in only about 25 per cent of the individuals that are homozygous for the pastel gene.

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IONIZING RADIATION AND THE CELL

THIS book* by D. E. Lea is published at an opportune time. The release of atomic energy has called for more extensive studies on the effect of short wave radiations on plant and animal life. Even in the field of radiation

*Lea, D. E. *Actions of Radiations on Living Cells.* Pp. 402. Strangeways Laboratory. The Macmillan Co., New York. $4.50. 1947.

therapy little is known about the cause of the biological response to X-rays. In writing this book Dr. Lea, a physicist, has had the cooperation of a number of eminent English biologists who have worked on the effects of radiation with viruses, bacteria, chromosomes and cells. The author has shown remarkable ability in presenting and correlating the physical and biological aspects of his subject.

The first chapter deals with the physical properties and dosimetry of different ionizing radiations — alpha, beta and gamma radiations of radioactive substances, X-rays, protons and neutrons. The chemical effects of ionizing radiations and the possible mechanisms of biological action are then discussed. An entire chapter is devoted to the target theory. The author recognizes the complicating factors which have led some investigators to abandon this theory, but he believes that it can be used in measuring the sensitive volume of viruses, bacteria and genes by using appropriate methods based upon the type of radiation, target size, and the amount of secondary radiation.

The discussion of radiation effects on viruses is of particular interest since, as the author points out, the viruses appear to occupy an intermediate position between living and non-living matter and there is a striking analogy between certain viruses and genes in respect to size, behavior and chemical constitution. Evidence is presented to show that the inactivation of viruses by radiation is due to a single ionization. There is also evidence that a single ultra-violet quantum is able to cause inactivation. The genetic effects of radiation are reviewed thoroughly including both point mutations and genetic changes caused by gross chromosomal alterations. Ultraviolet effects also are discussed and compared with the effects of ionizing radiation.

The remaining chapters—nearly half of the book—are devoted to the effects of radiation on chromosomes, cells, and organisms. The study of types and frequencies of chromosome aberrations following irradiation at various stages of the chromosome cycle and using varying doses, intensities and types of radiation have provided the data for an analysis of the mechanism of the induced chromosome structural changes. Experimental work with *Tradescantia* chromosomes has provided most of the data for this analysis.

The mathematical analysis shows that the breaks are caused by an ionizing particle capable of producing a number of ionizations within the effective target area. Most of the breaks undergo restitution within a few minutes. The type and frequencies of aberrations following different doses and different types of radiation permit an estimation of the number of ionizations necessary to cause a break in the chromosome.

The effect of radiation on cells and organisms is of particular interest in an atomic age. It is shown by investigators working with a great variety of cells that moderate doses of radiation, which could produce little chemical change, can cause the death of the cell although only at or following nuclear division. Such a reaction suggests that the effect is due to alterations of genes or chromosomes.

The author concludes the book with an appendix of supplementary calculations on energy dissipation, and target theory calculations with more technical mathematical analyses and accompanying tables.

Although many problems in the field of radiation biology remain obscure the author has shown what cooperation between physicists and cytologists can do in the early stages of a new science.

KARL SAX

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THE INHERITANCE OF CALLUS FORMATION AND SEED SHEDDING IN SORGHUM*

R. E. KARPER AND J. R. QUINBY†

IN their study of the inheritance of deciduous sessil spikelets in sorghum, Ayyangar, Rao, and Ponnaiga‡ found that callus formation and spikelet-shedding are conditioned by a monogenic difference, recessive to lack of callus formation and non-shedding. It has been observed during the past several years by the writers that callus formation is inherited as a dominant character in a number of segregating populations at the Texas Station. This paper is a report of the results of observations on these populations.

Two distinct mechanisms are involved in seed shedding in sorghum. The shedding of spikelets of varieties of sorghum (*Sorghum vulgare,* Pers.) cultivated in the United States is accompanied by the breaking of the pedicels. In Johnson grass (*Sorghum halepensis,* (L.) Pers.), Tunis grass (*S. virgatum* (Hack.) Stapf.), and Black Sudan (*S. versicolor,* Andress.), and a number of other grass sorghums that were introduced but never distributed in the United States, shattering or seed shedding results from abcission at a callus.

In all of the crosses, Tunis grass, a deciduous seeded variety, was one of the parents. Abcission at the callus invariably occurred in F_1 plants but it was not always easy to identify F_2 individuals if harvesting was done early enough to assure a seed supply from each plant so that the F_2 generation identifications could be verified in F_3. Since the several populations were all grown into the F_3 generation and the F_2 genotypes are known with certainty, it is these data that will be considered. The data are presented in Tables I and II.

Tunis grass was crossed with Texas Bh. kafir, Honey and Leoti sorgos, and Sudan grass. The F_1, F_2, and F_3 populations were grown either at the Lubbock or Chillicothe Substations during the years from 1933 to 1941.

An F_2 population of Leoti $\times$ Tunis grass consisting of 34 plants was grown into the F_3, and was found to be segregating for two genes (Table I). It appears that both genes must be present in the dominant condition before a callus is formed and a ratio of nine shedding to seven non-shedding plants occurs in the F_2. The F_3 rows were of four kinds: 1) homozygous dominant for both genes and all plants shed their seeds; 2) heterozygous for one gene and dominant for the other (three to one ratios for shedding to non-shedding); 3) heterozygous for both genes (nine to seven ratios of shedding to non-shedding; and 4) homozygous recessive for at least one of the two genes (all plants had seeds that persisted). These four kinds of plants occurred in the F_2 population in numbers that are within expectation if two independent genes are assumed. It is apparent that Leoti is recessive for two genes that are dominant in Tunis grass.

Sudan grass, Texas Bh. kafir and Honey crossed to Tunis grass gave F_1 plants that shed their seed and gave three to one ratios for seed shedding to non-shedding in F_2. It is evident, therefore, that Sudan grass, Texas Bh. kafir

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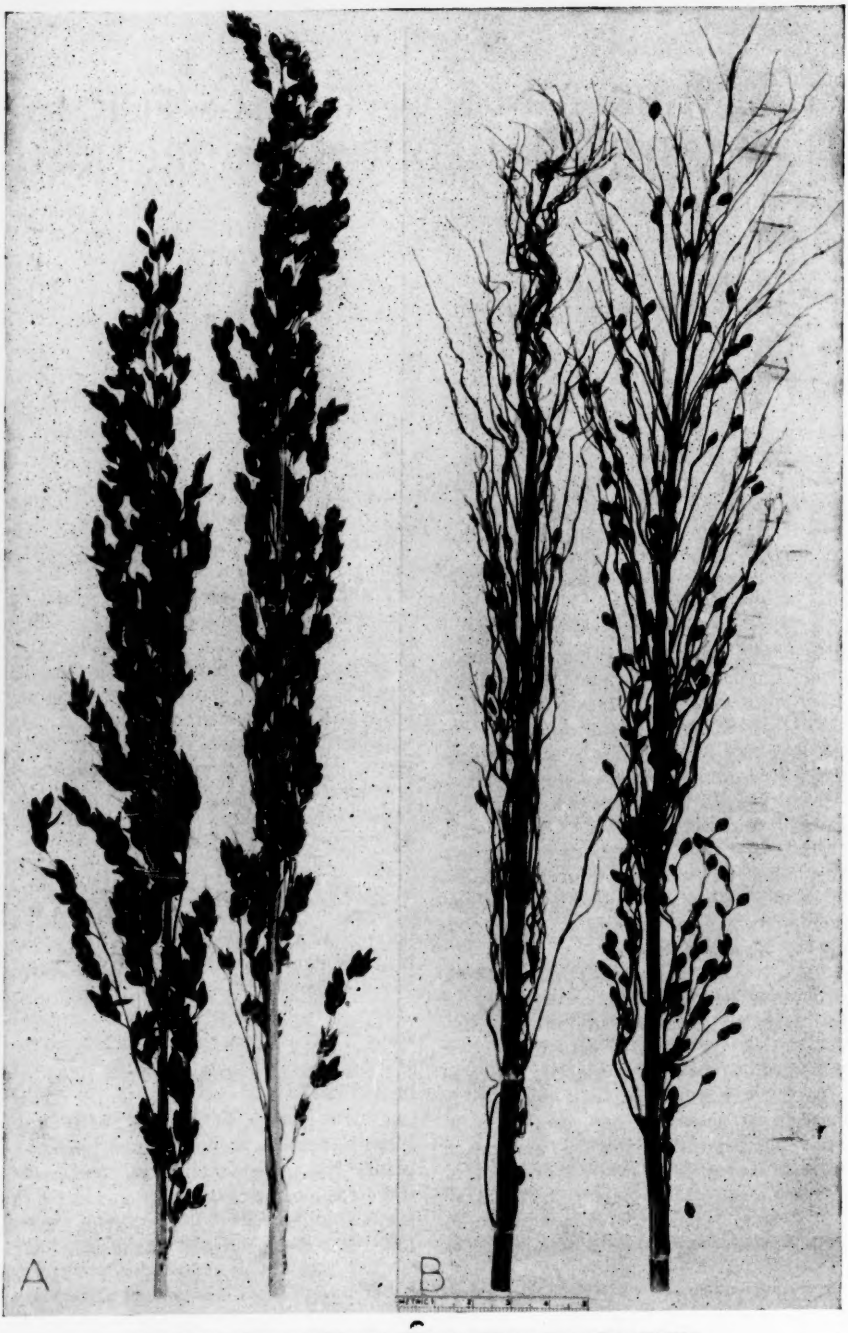
†The authors are Agronomist in charge of Sorghum Investigations and Agronomist, respectively, of this Division.

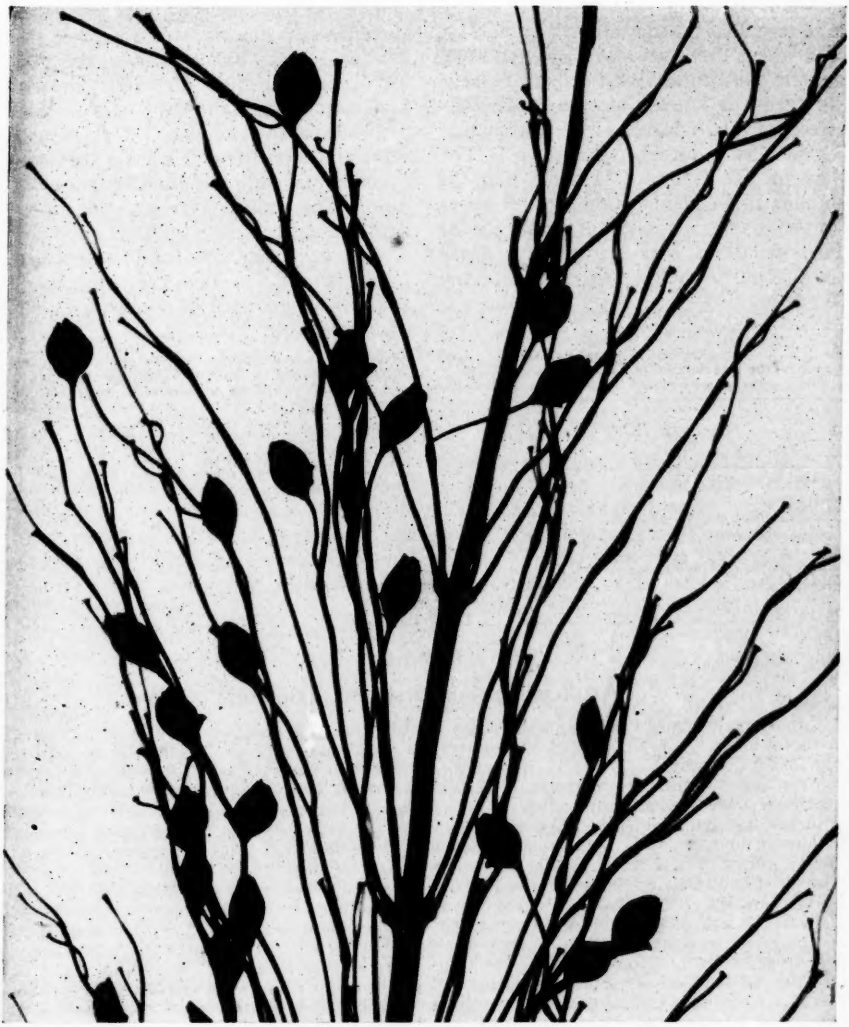
‡Ayyangar, G. N. Rangaswami, V. Pandurange Rao, and B. W. X. Ponnaiga. Deciduous spikelets in sorghum. *Current Science.* 6:299-300. 1936.



SEED-HOLDING VERSUS SEED-SHEDDING SORGHUMS

Figure 5

For description see next page.



DETAIL OF SEED-SHEDDING HEAD

Figure 6

Figure 5 shows heads of two types of sorghum, which differ with respect to the seed-shedding habit. The two heads at *A* are of a variety that does not shatter at maturity. The heads at *B* are of the shedding type, obviously a most undesirable characteristic with respect to the harvesting of the mature seed. Figure 6 shows a closeup of part of a head of a seed-shedding variety. Shattering is due to the formation of a callus layer just below the seed, at which abcission takes place. The cups from which the seeds have fallen are plainly visible. The formation of this callus is conditioned by two dominant genes, so that the breeding of non-shattering varieties is relatively easy.

and Honey are all dominant for one gene and recessive for the other (Table II). That these three varieties have the same genetic constitution with respect to these two genes is known because crosses between any two result in F_1 plants that do not form an abcission layer. The data in Tables I and II show that the number of F_2 plants in the several populations was small but the plants in the F_3 populations were numerous and the various phenotypes appeared in expected numbers.

These genes have not been located on chromosomes but it was observed that neither gene is linked with *q*, the gene for blackish purple plant color; or with *p*, the gene for tan plant color. Since Sh_1 has been assigned by Ayyangar, Rao, and Ponnaiga to a gene that produces non-shedding in the dominant condition, Sh_2 and Sh_3 are assigned to the two genes reported here. It is quite possible that either Sh_2 or Sh_3 may be found later to be identical with Sh_1 in spite of the reversal in dominance.

TABLE I. Classification of plants for shedding and non-shedding spikelets in an F_2 population of Leoti × Tunis grass as determined by observing F_3 rows.

Genotype	No. of plants	χ^2	P
Homozygous shedding. $Sh_2Sh_2Sh_3Sh_3$	2		
Heterozygous for one gene, dominant for other. $Sh_2sh_2Sh_3Sh_3$ or $Sh_2Sh_2Sh_3sh_3$	8		
Heterozygous for both genes. $Sh_2sh_2Sh_3sh_3$	8		
Homozygous non shedding. $Sh_2Sh_2sh_3sh_3$, $sh_2sh_2Sh_3Sh_3$, $Sh_2sh_2sh_3sh_3$, $sh_2sh_2Sh_3sh_3$, or $sh_2sh_2sh_3sh_3$	16		
Total	34	.150	.98

TABLE II. Classification of plants in three F_2 populations for shedding and non-shedding spikelets as determined by observing F_3 rows.

Cross	Number of plants in F_2 population: Shedding	Heterozygous	Non-Shedding	Total	χ^2	P
Sudan grass 58-5 × Tunis grass	8	15	10	33	.515	.70
Tunis grass × Tex. Bh. kafir	4	11	6	21	.620	.70
Honey × Tunis grass	9	31	12	52	2.270	.20

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Artificial Insemination in England

It is only recently that the question of artificial human insemination has attracted attention in this country. A conference on the subject has been held in London under the auspices of the Public Morality Council. The subject was discussed from every point of view by speakers representing the medical profession, the churches and the law. The problem was outlined by Dr. H. P. Newsholme, health officer of Birmingham. In the artificial insemination of a wife with her husband's semen he objected to obtaining the semen by masturbation as a lowering of human dignity. The only legitimate method was insemination from the vaginal pool after normal coitus. Mr. Kenneth Walker, a neurologist, who is an expert in male fertility, dealt with the use of donated semen. He had seen many more marriages saved rather than wrecked by this procedure. The theological aspect was dealt with by speakers representing the Roman Catholic Church, the Church of England and the Free Churches. Rev. J. C. Heeman, D.D., speaking for the Roman Catholic Church, condemned artificial birth prevention as "masturbation *à deux* and morally wrong. . . . For the Church of England Rev. G. L. Russell, a physician, . . . like all the clerical speakers, regarded the use of donor's semen as morally objectionable.

A lawyer, Mr. J. P. Ashworth, saw great legal difficulties in the use of donor semen. If pregnancy followed and the mother registered the child as her husband's she would be guilty of perjury. Also the child would be illegitimate. Legacies to the child in the belief that it was legitimate would be invalidated. Then there was the danger that children of the same father, ignorant of the fact, might marry and so be guilty of incest.

The case for artificial insemination was stated by two women doctors. Dr. Mary Barton said that artificial insemination had been a portion of her daily practice for five years. About 10 per cent of marriages were sterile, and in about 60 per cent of these the male was affected. In about 3 per cent he was hopelessly sterile. There was no greater disruptive element in married life than a fertile woman living with a man who could never give her a child. There was no stronger urge in the developed woman than the bearing of children. Adoption of children was a solution in only a minority of cases. In arranging for a donor of semen it was insisted that the matter should remain a secret. Appalling damage might be done to the child by the discovery that the man reputed to be its father was actually not. In an experience of 300 donor cases the results had been satisfactory. The children were healthy and the woman and her husband had been happy.—*J.A.M.A.* 34:1039, 1947.

GENETICS OF "SNOWY-BELLY" IN THE HOUSE-MOUSE

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IN 1941 a wild house-mouse (*Mus musculus*) with pure white underparts and light sandy-colored upper parts was caught in Virginia, and in 1946 the results of a preliminary genetic analysis of this "snowy-bellied" mouse were published by Eaton and Schwartz.[1] At first they supposed the character to be due to a new allelomorph of the agouti series. But after outcrosses to black-and-tan had been made, snowy-bellied mice were obtained, apparently by recombination, and this hypothesis was abandoned. As an alternative hypothesis, Eaton and Schwartz suggested that snowy-belly might be due to a single gene linked to the agouti locus, but the evidence in favor of this was very slight, and it was clear that a more detailed investigation was needed to determine the genetic basis of the snowy-belly character.

In the spring of 1946 Dr. G. W. Woolley very kindly sent a trio of snowy-bellied mice to this laboratory and the present writer began an analysis of the genetics of snowy-belly. The hypothesis that a single gene determined the character was soon found to be untenable, and the writer was forced to conclude that the snowy-belly of the mice investigated was a multifactorial character. The object of this paper is to present the evidence on which this conclusion was based.

Material and Methods

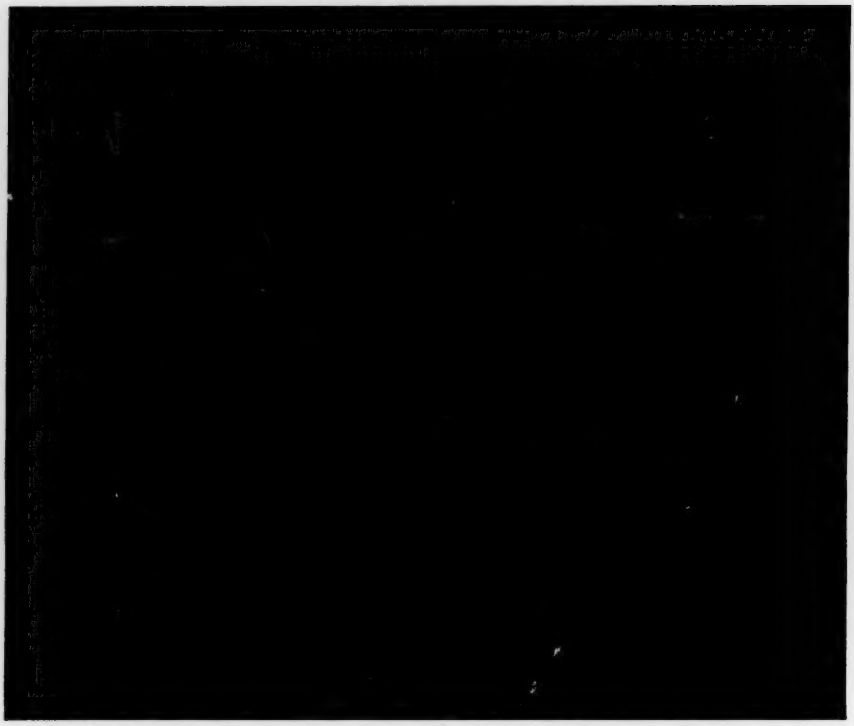
The snowy-bellied mice obtained from Dr. Woolley conformed to the description given by Eaton and Schwartz. Their bellies were nearly pure white, and their backs were much lighter in color than those of normal mice, owing to a widening of the agouti band in the hairs. After the stock was received it was maintained by close inbreeding, and no foreign germ-plasm was introduced. There was some variation within the stock, particularly in the whiteness of the belly, though no mouse was as dark as A^w mice usually are. The skin of a mouse from the snowy-belly stock is shown in Figure 8 on the left of the upper row. The genes carried at the agouti locus by the three original mice were at first unknown, but the results of the first matings soon showed all three to be of the genotype A^wa^t. Accordingly, in the first generation bred for stock, snowy-bellied black mice appeared, and the segregation of A^w and a^t was maintained in subsequent generations. Not all of the snowy-bellied black mice were pure white on the belly, though the majority were very much whiter than a^t mice usually are, and there was very little trace of the tan-colored "waterline" so characteristic of black-and-tan mice.

A number of outcrosses were first made to mice of known genotype at the agouti locus, in order to determine the dominance relations of snowy-belly, and its interactions with the agouti alleles. Backcrosses and intercrosses were then made in order to establish segregations of the gene or genes responsible for the snowy-belly character, and so to find out whether few or many genes were involved.

Results

1. *Outcrosses.* Difficulty was immediately encountered in classifying the outcross progeny, for no sharp distinction could be made between snowy and non-snowy bellies. Similar difficulties had been encountered by Eaton and Schwartz and were therefore not alto-

*Holder of Research Grant from the Agricultural Research Council. The writer is indebted to Professor R. A. Fisher, F.R.S., for permission to carry out the work in his labortory.



MULTIFACTORIAL SEGREGATION OF "SNOWY-BELLY" IN SIBLINGS

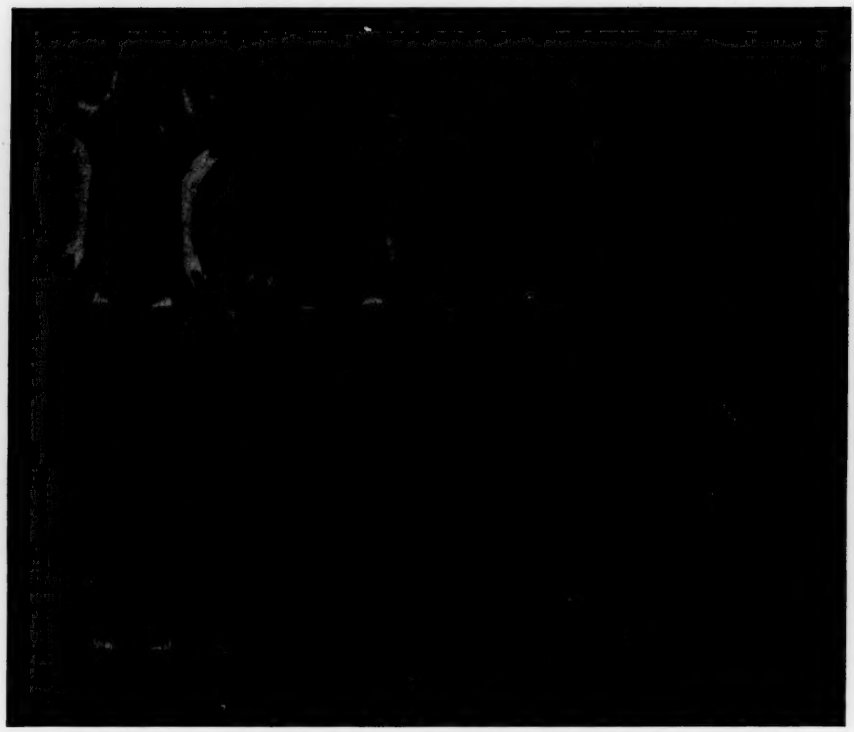
Figure 7

Skins from the bellies of mice three weeks old. All are of genotype $a^t a^t$, and the factors responsible for the snowy-belly character are segregating. The amount of pigmentation in the hairs forms a graded series, indicating that the expression of the character depends on the joint action of a number of genes.

gether unexpected. The outcrosses made, and the phenotypes of the progeny obtained from them, are shown in Table I.

The general conclusion drawn from these results was that snowy-belly was usually dominant in presence of homozygous "light-belly": that is, any combination of A^w and a^t. When either A or a was present heterozygously, snowy-belly was partially or fully recessive and the bellies of the outcross progeny were intermediate or non-snowy. The result of the last outcross in the table was, however, anomalous, because all the progeny, even though $A^w A^w$, were non-snowy. This result was probably due to darkening modifiers carried by the outcross mate, since this mouse had more yellow pigment on the belly than had the mice of the inbred strain that supplied most of the other outcross mates. This anomolous result suggested that the expression of the snowy-belly character was very susceptible to modification by minor genes as well as by the agouti alleles.

2. *Backcrosses and intercrosses.* The results of the outcrosses suggested that the situation was rather complicated, and before the investigation could be taken further it was necessary to find out whether the snowy-belly character was due to a single gene that could be made



SKINS OF MICE THREE WEEKS OLD

Figure 8

All skins except that on the left of the upper row, are of the genotype A^wA^w, and the factors responsible for the snowy-belly character are segregating. The amount of pigmentation on the bellies (seen as strips down each side of the skins) forms a graded series, indicating that a number of genes each with small effect are involved. The skin on the left of the upper row is from a pure snowy-belly house of genotype A^wa^t. Its belly is considerably lighter than that of any of the others.

to segregate in a recognizable manner. A number of backcrosses and intercrosses were accordingly made, but a clear segregation into distinct classes was never obtained; nor were bellies as white as those of the snowy-bellied mice ever recovered. It was evident, therefore, that the snowy-belly of the mice investigated was not due to a single gene. A description of two of the more critical matings will provide sufficient evidence for this conclusion.

The mating numbered *iv* in Table I, between a snowy-bellied A^wa^t mouse and an A^ya^t mouse from an inbred strain, produced snowy-bellied black (a^ta^t) progeny. One of these was then backcrossed to a black-and-tan (a^ta^t) mouse from the same inbred strain. The mating was thus homozyous for a^t, and since snowy-belly behaved as a dominant in the F_1, the mating was expected to produce snowy-bellied mice in equal numbers, if snowy-belly were unifactorial. Seventeen young were reared, and the amount of black pigment on their bellies formed a graded series, a division into two distinct classes being quite impossible. The young were skinned when three weeks old, and the photograph in

Figure 7 shows the belly skins arranged so as to show the gradation of color. These mice were born in two litters which are shown separately in the photograph, and it may be seen that the mice of the second litter, which occupies the bottom row, are darker in color than those of the first. It appears, therefore, that the color of the belly was also considerably influenced by non-genetic factors.

A snowy-bellied mouse, which was subsequently proved to be A^wA^w, had been mated to an A^wA^w mouse from another stock (mating *vi* in Table I), had produced non-snowy young. Two of these F_1 mice were mated together. This mating was homozygous for A^w, and, if snowy-belly were unifactorial, the mating would have produced two or three classes of progeny, according to the degree of dominance of snowy-belly. Nineteen young were reared from this mating, and again the bellies formed a graded series, with no suggestion of segregation into distinct classes. The skins of seven of these mice, chosen at random from two different litters, are shown in Figure 8, and they illustrate the nature of the variation encountered. A difference between litters was again apparent, because the four darkest skins, which occupy the lower row, came from one litter, while the three lightest came from another litter. The skin on the left of the upper row is of a snowy-bellied mouse from the stock, and it may be seen to have a lighter belly than any of the segregates.

The conclusion to be drawn from these results seems to be inescapable: the snowy-belly of the mice investigated was not due to a single gene, but was multifactorial. It is impossible to decide from the data available how many genes were involved, but it seems probable that the number was not very large, because a few mice with bellies approaching the whiteness of the snowy-bellied stock mice were recovered among the segregates.

TABLE I. Outcrosses of Snowy-Belly.

	Genotype of snowy ♂	Genotype of outcross ♀	Numbers & phenotypes of progeny	Character of belly
i	A^wa^t	*aa*	5 A^w : 3 a^t	non-snowy
ii	"	*AA*	8 A^w	intermediate or non-snowy
iii	"	*AA*	7 A^w	intermediate or non-snowy
iv	"	A^ya^t	12 A^y : 6 A^w : 4 a^t	snowy
v	A^wA^w	a^ta^t	6 A^w	snowy
vi	"	A^wA^w	11 A^w	non-snowy

Discussion

The evidence set forth above, from which it was concluded that the snowy-bellied mice investigated did not carry a single gene that determined the character, does not constitute a proof that such a gene was not present in the original snowy-bellied mouse investigated by Eaton and Schwarz. It is not impossible that before the stock reached the present writer a single 'snowy-belly' gene of major effect was lost from it by outcrossing, and its effect reproduced by the selective fixation of a number of genes each having small effects. Nevertheless, because the character investigated by Eaton and Schwarz was difficult to classify and was susceptible to selection, it is not improbable that it also was dependent on several genes each with small effect.

This interpretation, however, raises a difficulty: it cannot account for the appearance in a wild population of a single animal differing markedly from the rest of the population, as the original snowy-bellied mouse apparently did. The original snowy-bellied wild mouse may perhaps be accounted for in the following way. The length of the agouti band, and consequently the depth of color on back and belly, is a character that is very variable in both wild and domestic mice, and is easily altered by selection. It is therefore, presumably, under the control of a number of minor genes. According to Schwarz and Schwarz[4] truly wild *Mus musculus* have become commensal independently in several parts of the world, and on every occasion the domestication has been accompanied by a darkening of both upper parts and belly. Moreover, the reverse change (according to these authors) has also taken place; feral mice derived from

commensal stocks have often acquired again the light belly, at least to some extent. Now, the 'wild' mice of North America were derived (according to the same authors) from commensal mice introduced from Europe, and these presumably carried the 'dark-belly' allele (*A*) at the agouti locus. It is therefore reasonable to suppose that selection in the wild has lightened both back and belly by the accumulation of minor lightening genes on the *AA* agouti genotype. If in such a population a mutation from *A* to A^w took place, the major effect of this allele in combination with the minor lightening genes might well produce the extremely light phenotype seen in the snowy-bellied mouse. Mutations to A^w are by no means uncommon in either wild or domestic mice. (For references see Grűneberg[2], p. 30.)

The above hypothesis to account for the appearance of the original snowy-bellied mouse is put forward only tentatively, with the hope that those who are more familiar with the genetic structure of the North American feral mice will either confirm or refute it.

Finally it must be pointed out that even the snowy-belly phenotype may apparently be rather easily produced by means of natural selection. Jameson[3] described a population of house-mice inhabiting an island sand-hill in Dublin Bay, Ireland. This population was extremely variable in the depth of color on back and belly: some were as dark as ordinary domestic mice, while at the other extreme were mice with very pale upper parts and pure white bellies. The colored plate which illustrates these mice represents perfectly the appearance of the snowy-bellied mice investigated in the present study. There can be little doubt that the mice of the Dublin Bay sand-hill were derived from dark colored domestic mice, and that natural selection had produced the light color in a comparatively short time.

Summary

The genetics of a stock of 'snowy-bellied' house-mice was investigated, and it was concluded that the snowy-belly of this stock was not determined by a single gene, but was multifactorial.

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Social Science in the Soviet Union

DR. Darlington's article on "A Revolution in Soviet Science" in our May issue pointed out that genetic principles appeared no longer to be a proper subject for discussion in the Soviet Union—"They have already been decided." A communication to the *American Sociological Review* for June 1947 surveys social science research in the U.S.S.R., and reports a situation closely paralleling that in genetics.* The following excerpts from this article deal with points of especial interest in the light of the genetic revolution:

> . . . This theoretical emphasis on the possibility of changing society is associated with an emphasis on practical and applied results. One of the most important fields of practical activity open to the Soviet social scientists is that of propaganda. The head of the propaganda apparatus of the Communist Party and hence of the entire Soviet Union is a social scientist, G. F. Aleksandrov, who wrote a Ph.D. thesis on Aristotle and who now special-

*Moore, Barrington, Jr. Recent Developments in the Social Science in the Soviet Union. *Amer. Sociol. Rev.* 12:349-351. June, 1947.

izes in sociological theory.[1] The occupation of propagandist in the Soviet Union is completely free of the derogatory connotations sometimes associated with propaganda work in the United States. A propagandist is one whose task is to win public support and understanding for Communist Party policy in the detailed day-to-day work of a collective farm, industrial enterprise, trade union, or among the public at large. Modern social science training in the universities and elsewhere is directed towards turning out men and women who can do this work. Part of the training consists in getting actual practice by carrying on propaganda work in nearby factories.[2] A second outlet for practical work exists in the planning and other agencies of the government that have to carry out a great many statistical operations. I have not been able to find out what proportion of the social scientists are engaged in this type of research as compared with propaganda work and teaching, though Russian publications have surprisingly scanty references to the role of the Soviet social scientists in government agencies.

There are quite a number of indications of dissatisfaction with the system on the part of both the social scientists themselves and among those who exercise political and administrative control over them. Evidently the Communist Party did not feel that its controls were tight enough, as they have recently been strengthened. These actions represent a minor element in the strengthening of Party controls over all aspects of Soviet life.[3] In August of 1946 the Party Central issued a statement on "the backwardness of workers on the theoretical front," accusing them of pedantic erudition and escapist bookworming. "The scientific worker in our country," said the Central Committee, "is a public worker. He cannot be apolitical. . . . In his work he must guide himself by the policy of the Soviet government which reveals itself to be the living basis of Soviet society."[4] Shortly afterwards, the Party Central Committee in a slap at the Academy of Sciences, set up its own new academy of social sciences. This new academy has the specific task of training propagandists.[5] The old Academy of Sciences has in the meantime come in for rather sharp criticism and has been warned that it must attract new cadres of qualified workers to oversee the work of their scientific colleagues.[6] Direct evidence concerning the dissatisfaction of the social scientist himself with the strict system of control seeps into the press only rarely. However, aside from the escapist tendencies mentioned above, there are some indications that intellectuals and scientists in general have of late been reluctant to join the Party. *Pravda*, September 1, 1946, complained that at the University of Moscow, with over two thousand faculty members, including 83 Stalin prize winners, only five persons joined the Party in 1946. The poor state of Party propaganda work in other scientific institutes and the need for Marxist-Leninist education among scientists have been stressed on other occasions as well.

[1]Aleksandrov's rise to prominence has been rapid. Not mentioned in the *Brief Soviet Encyclopedia* of 1943, he won the Stalin prize for a *History of Western Philosophy* in 1946 and was elected to the Academy of Sciences in the same year. His position as Party propaganda chief is mentioned in *Pravda*, November 2, 1946; a brief biography on the occasion of his candidacy to the Academy of Sciences may be found in *Pravda*, November 27, 1946; his election to the academy is reported in the Russian press December 1, 1946. Quite probably he represents one of the new men promoted by the Party in competition with the older group of social scientists for reasons indicated in this article.

[2]A description is given in the report by the rector of the University of Leningrad, *Pravda*, October 14, 1946. The content of a shorter (two months) Party course is described in *Pravda*, September 13, 1946, as including the history of the Party, the Five Year Plan, domestic and foreign policy of the USSR, propaganda techniques, and lectures on philosophy, literature, and art.

[3]The strengthening of Party controls is surveyed by the writer in the *Review of Politics*, January, 1947.

[4]Unsigned lead article, "Soviet social science at the present stage." *Bolshevik*, No. 15, August, 1946, p. 7. (In Russian) *Bolshevik*, according to its masthead, is the theoretical and political journal of the Party Central Committee.

[5]The curriculum, etc., is announced in *Bolshevik*, No. 16, August, 1946. According to an account of the opening of the academy in *Pravda*, November 2, 1946, Stalin personally demanded the reorganization.

[6]*Pravda*, October 26, 1946.

GENETICS OF SESAME

IV. Some Genetic Variations in the Color of the Sesame Flower

D. G. LANGHAM

A STUDY of approximately fifteen thousand segregating populations of sesame (*Sesame indicum* L.), involving crosses among numerous varieties from many parts of the world, has provided material for analysis of some of the genetic variations in color and in morphology. Some of these color factors were mentioned in earlier abstracts,[1,2] but have not previously been described. The morphological variations will be the subject of a separate article.

With a little practice, all the color differences can easily be classified with the naked eye. In the preliminary stages of this work, a confusing set of ratios was encountered for most of the contrasting characters, but as the study progressed, several qualitative factors were isolated for each character. These gave simple Mendelian ratios. This is to be explained by the fact that in some siblings certain of the genes contributing this complicated inheritance become homozygous due to the segregation of several factors for each character under study. The F_3 and F_4 generations when the qualitative factors segregated separately were a striking demonstration of genetic principles. If only a few crosses had been made without a study of advanced generations, quantitative inheritance of some of the color differences might have been assumed.

One of the most interesting aspects of these investigations is that four different sets of factors determine the expression of each character. The *basic factors* determine whether or not the colors will manifest themselves; the *color factors* determine which type of coloring matter will be present; the *pattern factors* distribute the coloring matter if present, and, the *intensification factors* control the amount of coloring matter present.

Basic Factors

Basic factors are interpreted as those not adding any color in themselves but rather inhibiting the expression of the true color factors. It is supposed they block the chain of reactions leading to the development of color. One group inhibits the anthocyanins and the other the flavonols. In all cases studied so far, the genes which block the reactions are recessive. Thus we have the white flower variety isolated as a single plant selection in a variety from China in which no anthocyanin is developed; but the flavonol group is present. This is a single factor difference and segregates sharply. Another basic factor affecting the anthocyanin does not block the development of color in the exterior walls of the corolla, but eliminates the expression of a certain type of colored matter (known as *smear*) on the inside of the flower. Two similar factors block the development of the coloring matter known as *flake*. This makes a total of four known basic factors controlling the expression of anthocyanin. The one giving white flower is the most complete in its action.

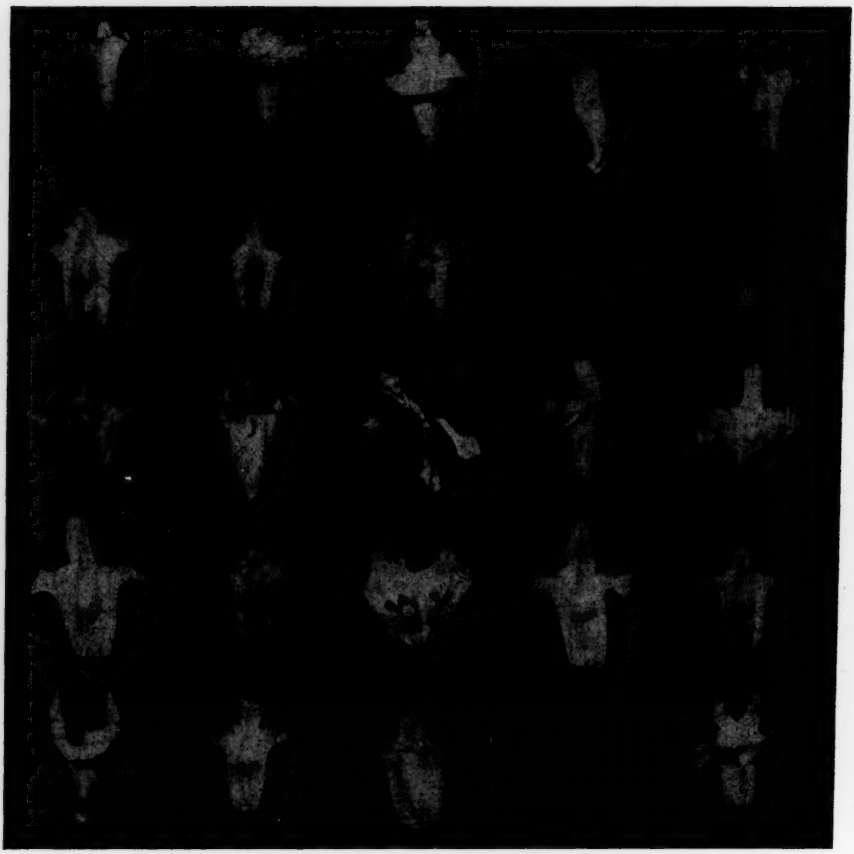
The flavonol group is completely blocked in the absence of a dominant gene which also segregates sharply as a monohybrid. The recessive gene was isolated in a variety from Brazil.

In view of the fact that known genetic material is necessary for the proper evaluation of the basic factors, it is extremely likely that others will be uncovered as this study progresses.

Color Factors

ANTHOCYANINS. If the basic factors for this group of color are present, then the following contrasting characters may be studied.

1. *Colored lip vs. white lip.*—The colored lip is most common among the



DISTRIBUTION OF COLOR
Figure 9

Flowers from 25 different plants, showing the diversity of the distribution and intensity of color. Note also the extreme diversity in the form of the flowers.

different varieties used in this study and has color in both the exterior and interior cell layers. The white-lipped type was isolated in a variety from Nicaragua. The interior wall is white but the exterior remains colored. White lip segregates as a simple recessive.

2. *Smear vs. non-smear.*—In the basal portion of the inside of the corolla of some flowers, a red coloring matter occurs between the two layers of cells. In other varieties this material is absent and the cells are white. In numerous crosses between these two types in many different varieties, six different ratios (3:1, 9:7, 15:1, 1:3, 7:9 and 1:15) have been observed indicating six different genetic factors. These include only the comprehensive ratios and not those confused by the segreation of many factors for *smear* in the same progeny. Most of the genes for *smear* occurred in varieties received from India and China.

3. *Flake vs. no flake.*—This color differs from *smear* in that the color is localized in small islands consisting of

five to ten cells isolated by tissues with no color. In the advanced generations of numerous crosses, five different ratios have been determined (3:1, 9:7, 15:1, 7:9, 1:15) indicating five genetic factors.

In crosses involving both *smear* and *flake* some of the F_2 ratios observed are: 3 flake: 1 smear; 12 flake: 3 smear; 1 white; 12 flake: 1 smear; 3 white: 9 flake; 6 smear: 1 white; and 48 flake: 9 smear: 7 white. These include only the F_2 ratios that have been confirmed by the observation of F_3 and F_4 generations. The study is far from complete.

4. *Color vs. no color in the axis formed by the upper two lobes of the corolla.* — Among the 85 varieties of sesame studied, approximately half have a reddish purple color in the axis formed by the upper two lobes of the corolla. The other varieties lack this color. Presence of color is dominant and segregates as a simple gene difference.

5. *Dotted vs. non-dotted.*—Some individual plant selections from a variety from Nicaragua had flowers with purple dots on the exterior part of the corolla. Progenies from these plants also had a dotted flower. In crosses with the normal types, the dotted flower reappeared in the F_2 as a simple recessive.

FLAVONOLS.—This group has proved to be more difficult to study than the anthocyanins because classification is not as simple. When only a trace of yellow color is present it is difficult to distinguish it from complete absence of color. Certain chemical tests have been useful in showing three types of yellow coloring matter. If a flower with yellow color in the foveola* and in the throat is placed in an atmosphere of ammonia fumes, the foveola becomes brown and the throat orange. The remainder of the previously white flower becomes yellow. If a flower from the same plant is placed in hot water after the yellow foveola and throat have been cut away, a yellow solution is formed from the white part of the flower.

Presence of yellow in the foveola described above is a basic factor which segregates as a simple dominant. The yellow throat on the other hand behaves as a recessive in crosses with white throated varieties. In the F_2 generations yellow throated and white throated flowers appear, but there are many intermediates which are difficult to classify properly. The chemical test will have to be used to study these differences.

Pattern Factors

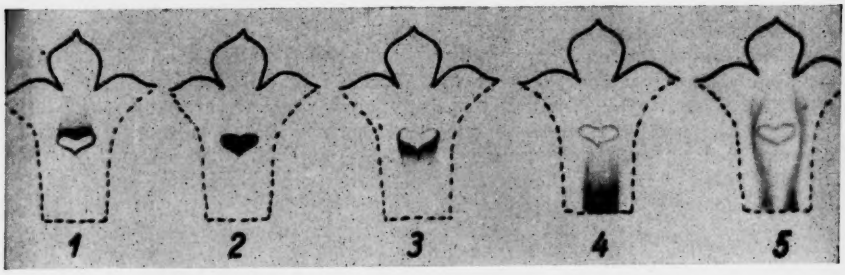
Independent of the basic factors and the color factors are those which distribute the coloring matter within the flower, giving definite patterns. These have been studied in reference to *smear* and *flake*. As shown in Figure 10 the red coloring matter of smear may be located in five different ways (1) above the foveola, (2) inside the foveola, (3) immediately below the foveola, (4) in the throat or (5) within the side walls of the corolla tube. These five patterns may be found separately or in various combinations. The pattern factor which governs the distribution of *smear* has a similar effect on *flake*.

The independence of pattern factors has been demonstrated by passing them through generations of colorless flowers and later recovering them in colored types. It has been found that the colorless flower used as a male carries a pattern factor for color inside the foveola as shown by the results obtained in the F_2 of the cross with a colored flower. The 9:3:4 ratio obtained, demonstrates the recessive pattern factor of the colorless male. As can be seen in the demonstration, known genetic material is necessary for the proper classification of pattern factors. The results obtained from studies in progress, will be given at a later date.

Intensification Factors

This is the fourth group of factors to be described which influence flower color. Like the pattern factors, they may be passed recessively through several

*The small indentation in the base of the flower tube.



COLOR DISTRIBUTION—THE "SMEAR" PATTERN
Figure 10

The sap pigments may be distributed in five different ways: 1—above the foveola; 2—inside the foveola; 3—below it; 4—in the throat; 5—outside the corolla base. Any combination of these may also be observed.

generations and later express themselves in crosses with colored flower types. When *smear* or *flake* is present, the intensification factors determine the amount of coloring matter. The color varies from only a trace to an intense red or purple.

In some crosses sharp segregation of color intensity has been observed, but in most cases there is a gradation from one intensity to another. Special crosses have been made recently for a better analysis of this problem.

Discussion

This may be considered a preliminary report of the genetic study of color differences in the flower of sesame. It is limited to 35 varieties and the many hybrids among them. Results obtained to date can be interpreted by assuming four general groups of factors, each independent of the other genotypically but with epistatic interactions in phenotypic expression. Each group consists of a number of qualitative factors which give confusing ratios when studied as a group, but which prove to be resoluble as unit differences when isolated in later generations.

These color differences have been useful in the preparation of a linkage map for sesame. The previously studied characters such as pod number per leaf axil were too few to determine linkage groups, but are useful in combination with the numerous flower variations now under study.

Summary

The color differences in the sesame flower are divided into four major groups; basic factors, color factors, pattern factors, and intensification factors. The number of genetic factors in each and their inter-relations with those of other groups are being studied.

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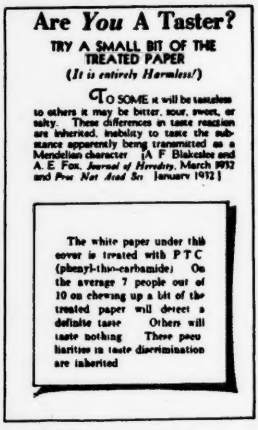
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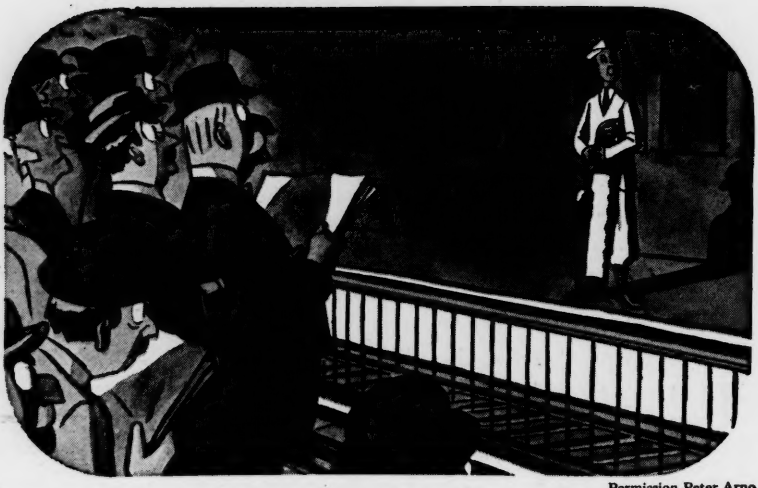

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